# RECORDS

OF THE

# GEOLOGICAL SURVEY

OF

# INDIA.

VOL. VIII.

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UNDER THE DIRECTION OF

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OF THE GEOLOGICAL SURVEY OF INDIA.

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Part 1.] 1875. [February.

## ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA, AND OF THE GEOLOGICAL MUSEUM, CALCUTTA, FOR THE YEAR 1874.

The labours of the Geological Survey of India have been, during the past season, almost entirely under the control and direction of Mr. H. B. Medlicott, who was officiating as Superintendent during my absence on leave. As stated in the report for last year, I remained for some time at Vienna arranging for the proper exhibition of the collections forwarded by the Geological Survey of India; this delay, however, did not tend to the improvement of my health, and I was in consequence not able to return to duty in India at as early a date as I had hoped. My first duty, on resuming charge of the survey, is now to express my high sense of the great zeal and energy with which Mr. Medlicott devoted himself to the duties imposed on him, and the wide knowledge of Indian Geological work and the high intelligence which he brought to bear on the researches of the survey, for which I am greatly indebted to him.

During almost the entire year, in addition to my own absence, the Geological Survey was also deprived of the aid of Mr. W. T. Blanford. He was, during this period, busily engaged in working out and passing to press the results of his examination of parts of Persia, while accompanying the Seistan Boundary Commission as Naturalist and Geologist. These researches, regarding a country but little known, and at the same time so intimately connected with Western India and Sind, will, I have no doubt, prove of very high value and interest to Indian Geologists. Their publication may now be looked for soon. Mr. Blanford resumed his duties on the Geological Survey about the middle of December, and then visited Surat district with a view to advise the authorities on the probabilities of obtaining fresh and good water in many places where now the supply is bad, salt, and brackish. Mr. Blanford has since then proceeded to take up the general examination of the Province of Sind.

Another of our staff who was absent at the commencement of last year, and whose return we looked for with great interest, has fallen a sacrifice to his over-exertion in the cause of science. Dr. F. Stoliczka, who had been, as reported last year, attached to the Yarkand mission under Sir T. Douglas Forsyth, had, though with much suffering, safely accomplished the journey to Kashgar, and had also on his return had a rapid and hurried ride across the Pamir Steppe, which he had often longed to see, and was returning to his work in India laden with rich and valuable zoological collections and with abundant notes to work out his results, when he again felt the extreme temperature of the Karakorum pass. For a couple of days from 16th June he worked on quietly, and though with suffering, continued the usual marches of the party with whom he was travelling. On the afternoon of the 18th, when more than half the day's march had been completed safely, he noticed something high up on the hill side, which arrested his attention, and dismounting from his horse, which, of course, could not climb up the rugged cliffs of these bare and snow-clad hill sides, he himself with great exertion struggled up, examined what he wished to see, and made his notes, and struggled down again to his companions. They noticed the great difficulty he found in again mounting, and came on to the camp slowly and carefully; the march next day was countermanded, in the hope that a little rest might enable our friend to recover himself, but falling into a semi-unconscious state, he only lingered on until the noon of the following day (19th June). His body was conveyed to Leh, where, with all possible honours, his remains were interred in the presence of his fellow travellers, the officers of the mission.

Thus passed away at the early age of 36 one of the most devoted and able votaries of Natural Science whom India has ever seen.

Gifted by nature with peculiar powers of observation and comparison, trained in an accurate and careful school of Geology and Palæontology, he brought to his labours unbounded zeal, acute intelligence, and large and carefully acquired knowledge, all of which tended to render him one of the most useful and most trusted of our colleagues. But in addition to this, his genial temperament, his sound judgment, and his hearty appreciation of work of any kind in others, together with his clear views of justice, and the unflinching expression of those views, made him also one of our most esteemed and beloved friends and advisers. His loss to the Geological Survey will be long and keenly felt. He has left behind him a noble monument of his research and powers in the Palæontologia Indica, published by the Geological Survey of India, in which, just before his departure for Yarkand, he had completed the description of the Cretaceous Fauna of Southern India in four large volumes 4to., with 203 plates. And fortunately for the Survey, he has also left behind him a very fitting and competent successor in Dr. Waagen, long his trusted fellow labourer and assistant. Dr. Waagen's publications have already secured for him the high approval of all competent to judge of such careful and accurate research.

Dr. Waagen himself was also absent on medical certificate during the year, and has only recently returned to take up the Palæontological labours on which he was so actively and earnestly engaged, when his health gave way. He has, I am happy to say, returned in good health.

Mr. Medlicott's time was so fully occupied by the current work of the survey, and by the pressing necessity for constant revision of the reports and researches of others, and unceasing communication and advice on all points referred to this office, that he found time for only two brief visits to the field. At the urgent request of the Government of Bengal, he undertook to visit the localities where coal was reported to occur within the Garo Hills. Until very recently, it was not possible to proceed into these hills with safety. And when formerly Mr. Medlicott visited the southern fringe of the hills (Memoirs, Geological Survey, India, VII, 151), and described the local exhibition of some poor coal-seams along their outskirts, no repetition of these rocks was known to occur within the range. But on now getting access to them, several detached basins of newer secondary rocks have been found in the heart of the hills, north of the main ridge. In one of these a strong seam of fair coal is pretty generally distributed. An account of this discovery was given in the May part of the Records of the Survey, 1874, p. 58, and it is therefore unnecessary to refer to it more in detail here. A short run into the northern portion of the Rajmehal Hills resulted chiefly in the discovery that no alluvial deposits occurred on the top of Putturghatta Hill north of Colgong, where they had been reported to occur, at a level which made it difficult to account for their existence, excepting on the supposition that the 'old alluvium' of Bengal had a marine origin.

Mr. Theobald continuing his researches in the upper tertiaries, flanking the north-western Himalaya, has made a rapid examination of the area lying between the Ganges and the Ravi. Some of his results, if confirmed by more careful investigation, are of high interest. He considers, apparently on good grounds, that the great mass of the Sivalik range on this side (east) of the Jumna river is really composed of rocks belonging not to the Sivalik group, but to the older and distinct Nahan group, a view in which Mr. Medlicott, who formerly examined this area, is disposed to concur. Trans-Sutlej, Mr. Theobald thinks he has established a northern limit for the Sivalik rocks along the Una dun. These are most interesting results, but as some of the most important palæontological deductions depend on these separations of the rocks in which the fossils occur, they must only be taken for the present as provisional.

Further research has led him to modify the conclusions arrived at in the previous season regarding the pre-Sivalik age of glacial deposits, for he finds typical glacial débris scattered irregularly over the rocks in the typical Sivalik area.

The collection of the very valuable fossils of these areas increases rapidly under Mr. Theobald's hands, and a large number have been received, the majority of which cannot be opened out for want of space in the Museum here.

Mr. A. B. Wynne commenced the examination of the Trans-Indus salt region early in the season. At the special request of Mr. Wynne, Dr. Warth, in charge of the Pind Dadun Khan Salt Mines, was deputed to accompany him, so as to form a sound practical estimate of the commercial value of these extensive salt deposits. Dr. Warth was unable to proceed with Mr. Wynne in the early part of the season, but subsequently joined him on the ground. This work was very well accomplished, and a brief summary of the geological results was at once submitted with the practical report of Dr. Warth. And this was published under the Revenue Department. Before the close of the year Mr. Wynne had completed a detailed descriptive report with full illustrations. And this is now in the press, and I trust will be ready for publication without any serious delay. Besides determining the enormous extent of the rock-salt, the most interesting result is the confirmation, in all probability conclusively, of the supposed old tertiary age of the rock-salt. This idea which had been arrived at during a cursory and preliminary examination in previous years was borne out by the careful and detailed investigation of the past season. No rock older than the salt has yet been noticed, and this salt seems to be intercalated with the lower beds or almost the base of the nummulitic rocks.

During the recess Mr. Wynne was also engaged in revising, and to a considerable extent rewriting, the report on the Salt-range. At the opening of the present season he took the field with the object of working up the country lying between the Salt-range and the Kashmir boundary to the north, and is now engaged in this area. He has sent in a good collection of fossils from the newer tertiary beds of that region, and also some from the small ridge of the Khárián or Pabbi hills on the east of the Jhelum river.

Mr. King, though unavoidably late in taking the field, in consequence of being detained at Vienna, has made, during the season, good progress in following up the interesting questions to which reference was made in the report of last year. He establishes three zones in the Rajmehal series: the uppermost characterized by a marine fauna recognized by Dr. F. Stoliczka as corresponding to his 'Oomia' beds in Kachh; a middle zone also containing marine fossils of somewhat different form from the preceding, and a lower zone with well marked Rajmehal plants. This last is found to be closely superimposed, but with general unconformity, upon beds containing plant remains belonging to the Kampti-Damuda flora, thus leaving little or no room for the zones which elsewhere are thought to intervene

These investigations detained Mr. Hughes, so that he did not get to his regular work until late in January. With Mr. Fedden's aid he then remapped the northern portion of the Wurrora coal-field, taking advantage of any recent exposure of the rocks in order to revise his geological lines. In a country so largely and thickly covered with alluvial deposits, it becomes necessary to pick out every single point so as to obtain any clue even of a trivial kind which may lead to the identification of the various rocks so badly seen. And this Mr. Hughes appears to have done with much care. It is gratifying to find that the practical conclusion based solely on such geological investigations, as to the existence of coal in the neighbourhood of Bander, has been fully confirmed by actual borings commenced entirely on Mr. Hughes' recommendation. These borings have proved the existence of coal many feet in thickness, the occurrence of which would never have been suspected from any surface exposure of the beds. This fact becomes of higher importance, because the locality of this coal is greatly nearer the very valuable iron ores of the country than any previously known beds of coal in the Wardha valley fields.

Passing into the Berars and the Nizam's territories, Mr. Hughes continued these investigations, and was able to give important advice and aid to the Nizam's officers.

It is a source of much regret that in consequence of the frequently recurring and continued interruptions to Mr. Hughes' progress in that district, the mapping of this Wardha coal-field is not yet completed. There is still a considerable area calling for careful examination, and in which it is not improbable that valuable results may yet reward our search. It would only cause greater delay to put any one else to complete this work now. And we can therefore only hope that it may yet be practicable without any much prolonged delay to complete the examination. The very existence of true coal in these districts and the sound knowledge already obtained of its extent and amount is altogether the result of the labours of the survey, and we should be glad to complete the investigation of the rocks as soon as practicable.

Towards the end of the year Mr. Hughes' aid was again sought for by two separate companies, who have undertaken to remove the all-important trial of actually smelting iron in this country from the field of speculation and writing to that of actual experiment on a commercial scale, in order to point out to them the most favourable localities for the procuring of ores, coal, &c., &c. He had scarcely concluded this work when the year closed. He will thus again have only a brief season to devote to his systematic work. He will, I am sure, do all that can be done in the time, but it will be entirely impracticable to complete the field in one short season.

Mr. Fedden, who, as stated in last year's report, had been absent on sick leave, did not return to work until late in January, 1874. He then joined Mr. Hughes in the Wardha valley field, and worked with him for the remainder of the season, putting in the detailed geological lines in parts of the Chanda district and in the adjoining territories of the Nizam. At one place north of Wurrora, Mr. Fedden was fortunate enough to discover a few specimens of fossil fishes in the uppermost beds of the sedimentary rocks, at about the same horizon as that on which the Reverend Mr. Hislop years since found similar remains. These will doubtless prove a valuable addition to the limited evidence we already possessed on which to base a conclusion as to the age of these beds. Mr. Hislop classed these rocks as belonging to the infratrappean beds of that neighbourhood in which he states that he found shells of the same kind as from the intertrappean layers, mixed with bones of large animals. On this evidence he referred the rocks to the same age relatively as the Lameta beds of the Narbada valley.

During the current season Mr. Fedden is attached to Mr. W. T. Blanford in Sind.

Mr. V. Ball only returned from the great exhibition at Vienna, where he had been, jointly with Mr. W. King, in charge of the valuable collections of the Geological Survey, late in the year. After some few unavoidable delays which prevented his getting to the field till towards the end of December, he was again frequently interrupted in his work in connection with the borings in the Dudhi valley. His survey labours were confined to the country included in sheets 17 and 18 of the Satpura Survey. He had made some progress in this area, when at the beginning of March, he was suddenly summoned to Calcutta, with a view to his accompanying some others on a visit to the Mergui Archipelago. This trip was subsequently abandoned, nor indeed under any circumstances could geological results of interest be looked for from such a visit to a country already examined. It was useless his returning to the field again after this trip was given up. Mr. Ball had thus only a very brief season of work, scarcely more than two months out of the whole season. It would scarcely be fair to look for any large outturn of work in this short time. The ground on which he was engaged was difficult, and the intricate relations of the various groups of rocks must all be more thoroughly elucidated and worked out before any descriptive account of them can be published.

Mr. Ball subsequently visited the wild district of the Luni Puthans, west of Upper Sind, where some traces of lignite had been seen. A full account of this visit has already appeared (Records, Geol. Surv., Ind., 1874, p. 145), so that it will be unnecessary to refer to it here in detail.

The experimental borings for coal in the region of the Narbada have not yet led to any discovery. Early in the year two borings were commenced, at Khapa and at Manegaon, in the valley of the Dudhi. These were in the Mahadeva rocks, and were put down in the hope of striking the coal-measures beneath. At the beginning of the monsoon these borings had reached 260 and 241 feet respectively from the surface, and were still in the covering rock formation, when the work was necessarily closed for the season. The labour was then transferred to the boring at Sukakheri in the main valley, where a depth of 344 feet had already been reached. There, it may be noticed, the endeavour is to reach the rock underlying the valley deposits, there being some grounds for supposing that the coal-measures of the Sitariva extend to the north. This boring has been carried down to the depth of 491 feet still in the stiff kunkur clay. The 3-inch piping having stuck fast at 425 feet, the additional depth was attained with great difficulty, until finally it was found impossible to do more than draw the sludge filling in from the sides; and the work had to be stopped. This boring had been commenced with such material as was available at the time, and with the full expectation that rock would be reached at a less depth. It had also the further disadvantage of frequent interruptions from want of piping; much credit is, therefore, due to the skill and energy of Mr. Stewart, that he was able under the circumstances to push the work so far.

No direct knowledge has, however, been gained upon the question to be solved excepting collaterally, that it would certainly be very costly to sink for coal through such a depth of superficial deposits. It may possibly be that these deposits are exceptionally thick at Sukakheri, and that rocks may be nearer the surface elsewhere, and the question would seem of sufficient importance practically, and of sufficient general interest to warrant a renewal of the trial in another spot. The lowest few feet of clay in the boring at Sukakheri were much charged with black ferruginous granules, single and agglomerated, suggesting perhaps the proximity of a lateritic bed which is by no means uncommon at the base of the old alluvial deposits, and this again most frequently occurs where the trap rocks occur underneath. Both these conditions are seen to obtain at several points along the margin of the valley.

Since the stoppage at Sukakheri near the close of the year, work has been resumed at Khapa and Manegaon, and progress has been already made beyond the depth attained before stopping for the monsoon. In December also two new borings were commenced in the Tawa valley, at Kesla and the Suk Tawa: the latter is certainly in the Dámuda rocks; the former is in lower Mahadeva beds. The hope is to strike the Barakur coal-measures, and thus, if coal be found, to save twenty miles of rough carting from the Shapur or Bétul coal-field to the south. As has already been fully explained, it is impossible to speak of success as anything more than a chance, inasmuch as no outcrop of these measures is seen north of the Shapur field.

Mr. Willson steadily continued his mapping of the northern portion of the Bundelkund Survey and finished several sheets of the 1-inch plans. One of the principal points of interest connected with this area is the great prevalence of quartz reefs or veins, having a very constant and definite direction and occurring in large number and of great size. There are also two systems of trap dykes in considerable number, and Mr. Willson finds evidence, which seems almost conclusive, that both these systems of trap-dykes are younger than the great quartz reefs, a conclusion of the highest interest as bearing on the geological history of the district. Mr. Willson has again resumed this work for the coming season. Mr. Willson's mapping is always distinguished by care, neatness, and accuracy.

Mr. Hacket resumed his labour in Rajputana, mapping in a large area of the country lying between Bhurtpur and Jaipur, and to the south, included in the sheets 27, 35, 37, 38, 39, and 41 of the Rajputana Survey, and in parts of 10*a*, 10*b*, and 12 of the Gwalior Survey, (scale 1 mile = 1 inch). All the rocks met with belong generally to the same class as those previously described by Mr. Hacket in the Biána hills, being chiefly quartzites, with very irregularly intercalated zones of schists, limestone, and trappean rocks resting upon or against gneissic masses. Mr. Hacket is disposed to adopt the name attached to the general range of these hills as a general inclusive name for the whole series of rocks, and to call them the Aravali series.

This work will be continued on Mr. Hacket's return from furlough, on which he is now absent. It has been for some time anxiously looked for, as tending to fill in one of the great *lacunæ* on the map of India, with a view to a general geological sketch of the country, and one of such importance that nothing very satisfactory can be done towards such a map until this portion of the country has been examined.

Mr. Mallet accomplished the examination of Sikkim (British) and of the Western Dhuars. The interest attaching to this field, from the probability of the coal forming an useful source of fuel, led to the publication of Mr. Mallet's report as quickly as possible. It has been issued with two geological coloured maps. Excepting in the Darjiling district his examination had to be limited to a mere fringe of the mountains; in places, indeed, even this much is beyond reach of the British boundary. There would appear to be some prospect of the Dámuda coal of that region being made serviceable by the adoption of suitable contrivances for the utilization of such dust or powdery coal.

Mr. Mallet's observations have led him to the conclusion that the Dámuda formation is, in this country, the lowest member of the rock series of the outer Himalaya ranges, the Darjiling gneiss being the topmost and youngest member of the same series. This, if confirmed, is a result of very great interest and importance, and would tend to establish a well marked common horizon between the rocks of the Himalaya and those of the Peninsula of India. Mr. Mallet's researches, excepting in the point to which his attention was specially directed, were necessarily rapid and cursory, and the maps can only be viewed as preliminary sketches. Until the country on either side is worked up to this portion, no really trustworthy or reliable section can be obtained from such isolated areas.

During the past year there have been four apprentices attached to the Geological Survey and paid out of the funds granted for that survey. Of these four, one has now been attached to the survey for nearly two years. During the present season he has been sent to the field with one of the assistants (Mr. Ball), who reports that up to date he has been attentive and willing to learn, but that his progress is very small and very unpromising. Further experience will be necessary before anything definite can be said as to the future prospect of this student. The other three, although nominated at the beginning of the year and receiving pay as apprentices, have been doing nothing in connection with the Geological Museum or Survey, having been, under the sanction of Government, attending courses of lectures and instructions at the Presidency College. Undoubtedly these lessons will enable them to appreciate better than they could otherwise have done the more technical knowledge which they are expected to acquire here. But the necessity for their devoting considerable time to this acquisition of what must be considered purely preliminary and collateral knowledge preparatory to any study of geology or its bearings, will also undoubtedly prolong the time during which they must be merely learning. It may, I think, well be doubted how far the system of paying young men for learning what they ought to be able to prove their acquaintance with, before their appointment, can be very successful. Certainly the system of giving appointments in order to induce the holders of those appointments to make themselves acquainted with their duties has, in every other scientific pursuit, proved a failure. These student apprentices will be subjected to examination at the end of the season, when their general progress can be tested.

As customary, a small map of India is annexed, showing the present rate and general progress of the survey.

Since the commencement of this survey it has ever been my anxious desire and aim to complete a general sketch map of the Geology of India. The conviction has grown stronger each successive year, that until this can be done, nothing really useful can be attempted in the direction of very detailed geology, and that our progress must necessarily be slow and irregular, until we shall have been able to fix even roughly the boundaries between the known and the unknown. I still hope that I shall be able to complete such a map. But I deeply regret to say that during the last few years, very little advance has been made towards the accomplishment of this end. There have been for some years so many and such urgent claims on the time of the officers of the survey for work of various kinds, often not geological, and the staff of the survey has been so reduced by illness and absence, as well as by actual diminution of numbers, that very little progress has been possible in that which has always been recommended to be, and which has indeed been more than once ordered to be considered the first and main object of the survey, namely, the systematic and continuous survey of the country. I am fully aware of the value of the results often obtained from enquiries in isolated areas, and at detached and separate points. Striking instances of this might be given from last year's work. Yet I am also compelled to think that these isolated enquiries are rarely of such immediate and urgent importance as to counterbalance the great and heavy disadvantage resulting from this very fact of their isolation. Each becomes a separate individual case, which it is impossible to colligate into a whole simply because we have no knowledge of the connecting links in the chain. Indeed many cases might be given where it seems more than doubtful whether anything is really gained even in time from such necessarily imperfect and unfinished results. A few years of devotion of the greater portion of the staff of the survey to this one object would enable such a general preliminary map to be published, subject of course to additions or corrections as the more detailed work progressed in future years.

A glance at the little map which accompanies this report will at once show what large areas there are regarding which the Geological Survey of India as yet knows nothing of its own research. But the difficulty in compiling a general map does not depend so much on the size or frequency of these gaps or *lacunæ*, for, of course, they could be left out, to be filled in afterwards, but on the fact, that without some knowledge of these intervening spaces, it is impracticable to correlate the rocks in one part of the country with those elsewhere. Each district or area examined in itself is necessarily described by itself, the rocks which occur in it are reduced to a system, their succession traced out, and their relations one to the other determined so far as possible. Local distinctive names are given to such separate groups, and all is rendered as complete as may be possible *for that area*. The survey operations are meanwhile directed to some other locality, and the same process of examination is gone through, but the results are not exactly the same; new sub-divisions of the rocks become necessary, new names are given to distinct groups, for local convenience of description. This result is equally correct and equally satisfactory for its own area. But for any general map, it becomes essential that all these differences should be eliminated, however roughly, and all reduced to one general system or scale, and this is precisely what it is impracticable to do without some knowledge, however imperfect, of the country generally, which knowledge there is no means of obtaining while the officers of the survey are engaged in isolated localities and on special researches.

Seeing then the very distant prospect which was before the survey of being able to work out any general map from their own researches, I have for some years devoted much attention to preparing separate descriptions and in some cases separate maps of certain divisions of the country, so far as these were possible. Passing over papers descriptive of the general geology of districts, or collectorates, (such as Surat, Gwalior, neighbourhood of Madras, Godavari, &c.,) a general sketch of the Geology of the Central Provinces was given so long since as 1871, of Orissa in 1872, of the Bombay Presidency in 1872, of the North-Western Provinces in 1873, of part of Punjab in 1873, and a general sketch of the Punjab is now just ready for press, while a general sketch of Bengal will be taken up also. These are all in addition to the regular and more detailed descriptions of separate areas, coal-fields, &c., &c. The most cursory reference to these sketches will show the impossibility of combining all into one system, without more knowledge of the intervening areas, as yet unexamined, or, as the other alternative, reducing the map to such large generalities as would get rid of these minor difficulties, but would at the same time make such a map of extremely little value.

It is our earnest hope, however, that the survey will be permitted to complete such a general sketch map as may prove useful and within a limited time.

PUBLICATIONS.—Of the MEMOIRS of the Geological SURVEY OF INDIA, Vol. X, part 2, announced as nearly ready at the close of last season, was issued early in the year. This contained a descriptive account of the Geology of Pegu by Mr. Theobald, with map, &c. And at the close of the year, part 1 of Vol. XI, containing a report by Mr. Mallet on the Geology of Darjiling and the Western Dhuars, with two geological maps, &c., appeared.

Of the RECORDS of the Survey, the usual quarterly publication was steadily maintained, and the volume for 1874 contains no less than twenty-three separate papers on varied points in the Geology of India. Four of these are valuable summaries of the geological results obtained during the visit to Yarkand with the mission recently returned from that country by our lamented colleague, Dr. F. Stoliczka. These with the note on the Altum-Artush, which will be found below, complete all that he had brought into shape for publication. Of practical papers, there are notes on the iron ores of Kumaon: on the raw materials for iron smelting: on Petroleum in Assam: on the subsidiary materials used in production of artificial fuel: on the building and ornamental stones of India: on Potash salts: on Manganese ore, &c., &c., while descriptive notices are given of parts of Northern Hazaribagh; neighbourhood of Murree; of Kangra; of the Garo hills; of the Luni Puthan country west of Sind, and of the Southern Godavari country. These with annual report, and an interesting paper by Mr. Theobald, on some speculations as to the antiquity of the Human race in India based on Hindu legends, form the volume for the year.

Of the PALÆONTOLOGIA INDICA, only one part was actually issued during the year 1874. As already stated in previous reports, the concluding parts of the Cretaceous Fauna of Southern India had been pressed forward in anticipation of their regular time of issue in order to complete this valuable series before the writer, Dr. Stoliczka, went away. This series was issued in full for the year 1873. And in addition, the commencing part of the Cephalopoda of Kachh by Dr. W. Waagen was published in anticipation of the regular time of issue, namely, for the first quarter of 1874. The absence with the mission to Yarkand of Dr. Stoliczka, and from ill health of Dr. W. Waagen, has prevented further publication during the year. Progress was, however, made in the preparation of plates and drawings, and since the return of Dr. Waagen, the continuation of his detailed descriptions of the Kachh Cephalopoda has gone to press. The part issued contained full description and figures of a very interesting form of Rhinoceros (*R. Deccanensis*) found by Mr. R. B. Foote in fluviatile deposits in Belgaum.

LIBRARY.—One thousand and eighty-four volumes or parts of volumes have been added to our Library during the past twelve months. Of this total more than one-half, or five hundred and fifty-seven, have been presented by different Societies and other institutions in exchange for the publications of the Geological Survey of India, or as donations, while five hundred and twenty-seven have been purchased. The usual quarterly lists of these have been regularly continued in the RECORDS of the Survey, and as customary, a summary of the various institutions from which donations or exchanges have been received during the twelve months is appended. We continue to render access to this very valuable library as general and as easy, as is consistent with the preservation of the books. And in very many cases, we find that from the special character of our collections, books have been available here, which could not be referred to elsewhere, either in Calcutta or indeed in India. In geological matters, quick and ready reference to the published results of other enquirers is perhaps more essentially necessary than in most other scientific enquiries, and we continue to look most anxiously for the transfer of our collections to premises where they can be rendered more easily accessible, and more generally useful, than it is possible to effect in our present greatly overcrowded apartments.

MUSEUM.—During the year all the collection forwarded to the International Exhibition at Vienna, which was intended to be returned to this country, was safely received back, and was again embodied with the general series. General notices of donations have been given in the Records for the year, while we continue to receive from the officers of the Survey itself valuable additions constantly. Of the so-called Sivalik fossils, a large and valuable series has been procured by Mr. Theobald in his recent examination of the country. The examination in detail of these is, I regret to say, almost completely impracticable from want of any space or room in which to open them out, though individual specimens have been taken up. But very important results bearing on the sub-division and age of the different horizons of these rocks and of the imbedded fossils will undoubtedly arise, as soon as they can be carefully compared and described. From Mr. A. B. Wynne also a good series of similar fossils have been obtained, procured from parts of the Rawal Pindi and Jhilam districts in which he has been working, and from the small range of hills on this side the Jhilam, called the Pabbi hills. Some fish remains and other things were procured by Mr. Fedden, and a good series of specimens from the upper, secondary, and tertiary rocks of the Lower Godavari basin by Mr. King. To Mr. Hughes also the Museum is indebted for a very interesting series of fossils from the country adjoining the Milam pass, to the north of Kumaon, which prove the continuity of the formations first described as occurring near the Niti pass by Colonel R. Strachey: thus extending our knowledge of these formations considerably north-east. The fossils represent at least five different formations, Cretaceous, Jurassic, Triassic, Permian, and Carboniferous and Silurian. A detailed list will be given in a future number of the Records.

METEORITES.—Our series has been enriched by pieces of the fall which took place on the 23rd September 1873. These are of much interest from the fact of their having been procured at different places, though the structure and composition of the stones show that they are identical in their nature. One piece was found near the village of Mylsi, fifty miles to south-east of Múltan, and two others at Khairpur, thirty-five miles east of Bhawulpur. The distance between the two places being probably more than ten miles.

The collections have been kept in good order and safety during the year.

T. OLDHAM,
*Supdt. of Geol. Survey, India,*
*and Director of Geol. Museum, Calcutta.*

CALCUTTA,
*January*, 1875.

*List of Societies and other Institutions from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year* 1874.

BATAVIA.—Royal Society of Batavia.
BERLIN.—German Geological Society.
DITTO.—Royal Academy of Sciences.
BONN.—Naturhistorischen Vereins.
BOSTON.—Society of Natural History.
BRESLAU.—Silesian Society.
BRISTOL.—The Naturalists' Society.
BRUSSELLS.—Royal Academy of Science.
CALCUTTA.—Agricultural and Horticultural Society.
DITTO.—Asiatic Society of Bengal.
CAMBRIDGE, MASS.—American Academy of Arts and Sciences.
DITTO.—Museum of Comparative Zoölogy.
CAMBRIDGE.—Woodwardian Museum.
COPENHAGEN.—Royal Academy.
DIJON.—Imperial Academy of Dijon.
DRESDEN.—The Isis Society.
EDINBURGH.—Geological Society of Edinburgh.
DITTO.—Royal Scottish Society of Arts.
DITTO.—Royal Society.
GLASGOW.—Geological Society of Glasgow.
DITTO.—Philosophical Society.
GÖTTINGEN.—The Göttingen Society.
LAUSANNE.—The Society of Natural Sciences.
LIVERPOOL.—Literary and Philosophical Society of Liverpool.
LONDON.—British Museum.
DITTO.—East India Association.
DITTO.—Geological Society of London.
DITTO.—India Office.
DITTO.—Royal Institution of Great Britain.

LONDON.—Royal Society.
DITTO.—Royal Geographical Society.
MANCHESTER.—The Manchester Geological Society.
MELBOURNE.—Royal Society of Victoria.
MOSCOW.—Imperial Society of Naturalists.
MÜNICH.—Royal Bavarian Academy of Science.
NEUCHATEL.—Society of Natural Sciences.
NEW HAVEN.—Connecticut Academy.
NEW ZEALAND.—Geological Survey of New Zealand.
PARIS.—Geological Society.
DITTO.—L'Administration des Mines.
DITTO.—National Institute of France.
DITTO.—The Academy of Sciences.
PEST.—Royal Geological Institute of Hungary.
PHILADELPHIA.—Academy of Natural Sciences.
DITTO.—American Philosophical Society.
DITTO.—Franklin Institute.
ROME.—Geological Commission of Italy.
SALEM, MASS.—Essex Institute.
DITTO.—Peabody Academy.
STOCKHOLM.—Bureau de la Recher. Geol. Suede.
ST. PETERSBURG.—Imperial Academy of Sciences.
TASMANIA.—Royal Society.
TOKEI.—Geological Survey of Yesso.
TORONTO.—Canadian Institute.
TURIN.—Royal Academy of Sciences.
VICTORIA.—Government Geological Survey of Victoria.
DITTO.—Ditto ditto ditto, Mining Department.
VIENNA.—The Vienna Academy.
DITTO.—K. K. Geologischen Reichsanstalt.
WASHINGTON.—Department of Agriculture, U. S. A.
DITTO.—Smithsonian Institute
DITTO.—United States Geological Survey.
WELLINGTON.—New Zealand Institute.
YOKOHAMA.—German Natural History Society.
ZÜRICH.—Natural History Society.

Governments of Bengal, Bombay, India, Madras, North-Western Provinces, and Punjab; Chief Commissioners of British Burma, Central Provinces, Mysore, and Coorg; the Resident, Haiderabad, the Surveyor General of India, the Superintendent of the Great Trigonometrical Survey of India, and the Superintendent of the Thomason College of Civil Engineering, Roorkee.

*January*, 1875

## THE ALTUM-ARTUSH CONSIDERED FROM A GEOLOGICAL POINT OF VIEW, *by* F. STOLICZKA, PH.D.

(*Veni, sed non vidi.*)

As soon as the most important political business had been concluded by the signing of the commercial treaty by the Amir, His Excellency Mr. Forsyth expressed a wish to visit the renowned tomb of Sultan Satuk at Altum-Artush. The king accorded his permission, and instructed the Hakim Mahomed Khoja to assist us in travelling over the province under his care to whatever extent Mr. Forsyth might desire.

Under the personal guidance of the Envoy, we—Dr. Bellew, Captain Chapman, Captain Trotter, and myself—left Yangishar on the 14th of February, reaching Altum-Artush at a late hour the same day. As an introduction to the difficulties in travelling, our baggage did not arrive till next day, and we had to accommodate ourselves for the night on the carpets of the floor in a spacious but tolerably warm room. A halt of two days was desirable to enable us to make all necessary arrangements for our further movements. However, before I proceed, I shall endeavour to give the reader an idea of the geographical position and limits of the country of which I shall speak in the subsequent lines.

The data are derived from a general survey by Captain Trotter and from information given by the Hakim Mahomed Khoja.

Altum-Artush, which is the chief place of the province, lies approximately in east long. 76° 8′ and north lat. 39° 41′, therefore about twenty-three miles north by east of Yangishar. It is situated in the western part of the Yilak on the Bogos, here called Artush river, and north of a low ridge which separates the Artush valley from the plains. The southern boundary runs along this ridge for about ten miles west of Altum-Artush, and from there almost due north to the crest of the Koktan range; then along this range eastwards of the Belanti pass (east long. 77° 47′ and north lat. 40° 41′), and from thence in a south-eastern direction to the village of Kushtignak, some fifteen miles north of Fyzabad in long. 76° 42′ 30″ and lat. 39° 28′ 30″. From here the southern boundary runs close to the right bank of the Kashgar river, until almost opposite to where the Artush river runs into the plains.

During the first four days we all marched in company up the valley of the Bogos river to the fort Tangitar, about twenty-three miles to the north by west; then to a Kirghiz camp, Bashsugum, in a north-easterly direction; Tugurmatti almost eastern; and Ajaksugun in a south-eastern direction; the directions being from the last camps respectively.

At Azjak-sugun Captain Trotter and I separated from the rest of the party, marching northwards along the road to Ashtifan, to Jaitava, and from thence across the Jigda Jilga in a north-east by east? direction to the camp at Nibulak, crossing the Nibulak pass, passing a second jilga, and turning then for almost nine miles more northwards to the Belanti pass, beyond which lies the valley of the Kakshal or Aksai river. On our return we passed Ayak-sugun, Karaul, about a mile from our former camp of the same name, and visited Kultislak and Fyzabad, returning to Yangishar on the 3rd of March.

It was not a very favorable time for travelling in these regions, not so much on account of the cold, as in consequence of the heavy falls of snow which appear to occur over the whole of Thianshan during the second half of February and first half of March. During the last few days of February we were almost constantly wading in fresh fallen snow, though on the saline plains it melted very rapidly.

The snow naturally interfered seriously with our observations. However, obtaining even but a little addition to our knowledge of these hills, was a better way of occupying our time than remaining in our somewhat gloomy quarters.

From a geological point of view the trip proved in many respects to be of considerable interest, particularly as supplementing some former observations made more to the west. Although there is not much variety in the rock formations we may distinguish three successive series. The most southern part of the province, along the foot of the hills, is formed of alluvial gravels and sand in whose unfathomable depths are swallowed both the Artush and Sujun rivers, before they can reach the Kashgar daria. Wherever irrigation from the latter is possible the fields appear to be fertile; but in the contrary case, the land is not much more than a mere desert covered with low and scanty scrubs of *Ephedra* Sp.? The marshy grounds along the river are the breeding places of innumerable waterfowl. Brahmini ducks and pintails were already selecting sites for their nests on the 1st of March. The latter must have only just arrived.

Where high grass occurs wild pigs are not uncommon.

The second series includes the low hills which extend diametrically from north to south over about thirty miles, while the prevalent strike is from north-east by east to south-west by west. All these lower hills are occupied by Artush beds, of which I spoke in a former communication. They are separated into two groups. The lower beds consist of greenish or reddish clays or sandstones, and the upper ones of coarse conglomerates, which on a hill south of Tangitar have a thickness of about a thousand feet. At their contact both groups generally alternate in several layers. An anticlinal runs almost through the middle of their superficial extent. At the fort Ayak-sugun it is caused by a low ridge of old dolomitic limestones on which the Artush clays and sandstones found a firm support. To the south of it the beds dip at angles of about 40° and 50° towards the Kashgar plain, in remarkably regular and successive layers. North of the ridge, which has no doubt a considerable subterranean extent in an east to west direction, all the beds dip towards north by west at a similar angle. Approaching the higher range more recent diluvial gravels cover most of the slopes. The geological puzzle of finding strata of young beds as a rule dipping *towards* a higher range composed of comparatively much older rocks seems to me to be due, at least in this special case, to the phenomenon that the atmospheric waters which, descending on the crest, flow down the slopes of the high ridge, gradually soften them, and if a subterranean outlet facilitate it the softened beds are worn away. While this process is going on the more distant beds simply subside in order to fill the vacant spaces. In some cases a sinking or rising of the main range, or even an overturn of high and precipitous cliffs, seem to go hand in hand with the action of erosion, but it is not always the case. I hope to illustrate this idea by a few diagrams, partly derived from actual observations on some future occasion.

A third series of entirely different rocks forms the main range of hills which are a continuation of the Koktan range, and in which, more to the westward, are situated the Terek and Chakmak forts. The average height of the range is here between 1,200 and 1,300 feet, single peaks rising to about 1,500 feet. The whole of the southern portion consists, as far as I could see, of carboniferous rocks, in which, however, there is a great variety of structure. The lowest beds are very often a peculiar breccia-limestone passing into regular limestone conglomerate. Above this are beds of solid grey dolomitic limestone, partly massive, partly stratified; the former possessing the character of reef limestone, and portions of it are indeed full of reef-building corals, crinoid stems, and a large *Spirifer*, the sections of which, when seen on the surface, have a striking resemblance to those of *Megalodon*.

North of Tangitar and about Bash-sujun I met in several places great numbers of fossils, but they were so firmly cemented in a calcareous matrix that only a few could be extracted. Among these I could recognise a small *Bellerophon*, *Productus semireticulatus*, and an *Athyris*. A new *Terebratula* was also very common. Here about Bash-sujun and Tugurmatti greenish shales occurred often interstratified with the limestones, beds of which were highly carbonaceous; the shales appeared to be unfossiliferous.

The limestone hills, which, as already stated, are a continuation of the Koktan range extend in a north-easterly direction the whole way to south of the Belanti pass, where they are overlaid by a particularly well-bedded dark limestone very similar to that containing *Megalodon* north of Chungterek. On this limestone rest greenish and purplish sandstones and shales which occupy the pass and the adjoining hills to the north-west of it; mineralogically these last rocks are quite identical with what we understand under the name of "*Bunter sandstein*," and it is by no means improbable that the Belanti beds are also of triassic age, as they succeed in regular layers those of the carboniferous formation.

A peculiar feature in this part of the hills consists in the occurrence of extensive plains to which the name *jilga* is generally applied. It means originally, I think, merely a water-course, and, on a large scale, these plains may be looked upon as water-courses of former water-sheets. They occur at the base of the high range, and in some respects resemble the *dúns* of the southern slopes of the Himalayas. North of Tangitar one of these large plains occurs within the limestone rocks, being surrounded by them on all sides. It must be about thirty miles long from east to west, and about sixteen from north to south. Several isolated limestone hills and ridges occur in it, and it is drained off by the Bogos and Sujun rivers, the former rising in the south-west, the latter in the south-east corner. The average elevation is about 5,000 feet. The greater portion is covered with a low scrubby vegetation, and, near the rivers, with high grass. The principal camping grounds are Bash-sujun and Tugurmatti. The whole plain, which affords a good pasturage ground, is occupied by about 120 tents of Kirghiz during the summer.

The next jilga is the Jigda Jilga. It differs considerably both in its physical situation and in its general character from the former. It stretches from west by south to east by north for about thirty-five miles, while the diameter of the eastern half is about twenty and that of the western about twelve miles. Save for a few low hillocks it is almost a level plain throughout. On the north-western, northern, and north-eastern side it is bounded by the Koktan range, from which several water-courses lead into it, one about the middle from the north and one from north-east of considerable size, this containing a large quantity of crystalline pebbles; the rock from which they are derived must be *in situ* near the axis of the ridge. A third big stream comes from the east, leading from the Nibulak pass. None of these streams had any water in them. On the south, east, and south-east the plain is bounded by the much lower hills composed of Artush beds, their slopes covered with gravel.

An elevated gap or saddle situated in the south-west corner appears to connect this jilga with that of Tugurmatti. There is no drainage from this jilga; all the water is absorbed by the enormous thickness of sand and mud which fills the entire basin. This accounts for the comparatively rich vegetation which exists in it. There are several stretches of regular poplar forest (*P. nigra* or *P. balsamifera*) up to ten miles long and four to five miles in breadth. Besides which there are several places occupied by regular jungle of *Tamarix*, *Myricaria*, *Ephedra*, and the peculiar wormwood, from the seed of which the Kirghiz prepare *satú*. The *Tamarix* and poplars must absorb during their growth a very large quantity of the mineral salts with which the entire ground is saturated; the wood on being burnt gives out a strong smell of sulphur and chlorine.

The poplar trees are not healthy; they resemble oak trees covered with mistletoe. The branches are short, stumpy, and bushy. It is evident that the trees only exist in consequence of the subterranean moisture. There are a great number of springs through the forest and on its edges, but on account of the level character of the plain no flowing streams exist except where there has been a very heavy snowfall and very rapid melting.

Jigda Jilga is occupied by about 150 to 170 Kirghiz tents; each tent may be taken as containing five souls. There are a few fields near Jigda camp, and if there has been a large quantity of snow the crops are said to prosper very well. During the winter the Kirghiz are encamped in small groups near the different springs. They do not keep many horses, but large numbers of sheep and goats and a few camels. One whole *akoi* is a light load for a camel; when packed the blankets are made into saddles over the hump of the animal.

A third jilga is south of the Belanti pass and north-east of the Nibulak pass. It is about eight miles in breadth and the same in length. There are two large water-courses leading to it from the range. On the southern side it is enclosed by Artush and gravel beds, but whether an outlet exists is not known. It has no forest, nor any kind of trees or large bushes, and the grass vegetation is scanty, evidently on account of the dryness. A southerly outlet very likely exists. We met a few Kirghiz encamped here from Ush-Turfan. The only supply of water they had was melted snow, and as soon as the snow-beds about are exhausted, they have to retreat with their flocks to the Kakshal valley.

## ON THE EVIDENCES OF 'GROUND-ICE' IN TROPICAL INDIA, DURING THE TÁLCHÍR PERIOD, *by* F. FEDDEN, F.G.S., *Geological Survey of India.*

Since the announcement by Mr. Blanford in 1856 (Memoirs, Geological Survey, India, Vol. I, page 49) of the occurrence of deposits supposed to be glacial in formations occupying the low lands of India south of the Tropic—those formations, moreover, being presumably of palæozoic age—the fact has hardly engaged the attention due to one so opposed to every-day experience at present. This neglect must, of course, be in a great measure attributed to doubt. Even among ourselves, observers of the Tálchír boulder-clay have subsequently attempted to offer explanations of its mode of formation without the agency of ice. But this view never obtained favour from those having the largest acquaintance with the deposits in question, who have confidently looked forward to the confirmation of the judgment given by Mr. Blanford.

Although it had been pointed out from the first, that the mode of ice-action involved was of a kind in which striation would be the exception rather than the rule, still, striation was almost the only independent testimony to be looked for in confirmation of the general evidence. The boulder-bed had no resemblance to the till, or the deep-moraine, of a continental ice-sheet, except perhaps that the fine greenish silt so frequently forming the matrix of the boulder-bed has a great similarity to the well-known glacial mud. It was equally unlike the ordinary moraine deposits of glaciers; the boulders exhibit, most commonly, considerable weathering or water-wear. The boulder-bed, too, is not usually a bottom bed, but is generally intercalated with very regular and sharply bedded deposits. Lamination is moreover not unfrequently displayed in the boulder-bed itself. These features all point to the familiar circumstances accompanying ground-ice, where loose materials are picked up by the freezing of the water in rivers or on the shallow margins of water-basins, and floated away to be deposited elsewhere. Even so it must happen that such ice-rafts get stranded with more or less violence, producing striation and polishing of the imbedded boulders and of the rocks with which they may come in contact, as also when urged onward by the accumulating force of an ice-blocked river. It was therefore confidently expected that sooner or later evidence of this kind would be forthcoming in the Tálchír boulder-bed.

In January 1872 I had the good fortune to find an excellent example of this missing link of evidence. The place was visited shortly after by Dr. Oldham, who dug out and removed a fine specimen of hard dense close-grained syenitic granite, of which one side is beautifully polished, scored and striated. This specimen is now in the Museum of the Geological Survey in Calcutta. Notice was given of the discovery at the time by Dr. Oldham in a foot note to a paper by Mr. Blanford on the Geology of Nágpúr (Mem. Geol. Sur., India, Vol. IX, p. 324).* The section was not then very well seen. But on revisiting the ground during the past season, I found the rocks much better exposed. A special record of the case is made, as it is not unlikely that the elements may before long obliterate what they have now laid bare. The locality is near the little village of Irai on the right bank of the Pem river, not quite a mile above its confluence with the Wardha, and ten miles to west south-west of Chánda.

The surface features of the neighbourhood for a considerable distance always form an important consideration in the discussion of any particular case of ice-scratching; and even for these most ancient deposits we are not without some plausible conjectures on this point. From the very general fact of the Tálchír group, and the other lower members of the series to which they belong, occupying low ground in the actual drainage basins, and being commonly overlapped by the succeeding members of the series, it is apparent that the actual basins are in a manner the reproduction of the pre-Tálchír ground-configuration. No doubt the ancient highlands had been greatly denuded to furnish materials for the thick deposits overlying the Tálchírs; and they must have suffered further reduction from the denudation which has for the most part removed again those overlying groups. Yet it is probable that the existing contours give an indication of the pre-Tálchír surface. If it be so, there is nothing here to support the notion of a glacier having reached the spot under notice. For many score miles round there is no commanding elevation of rock older than the Tálchírs from which an ice-stream could have descended. The supposition of an expansive ice-sheet would be still more difficult to reconcile with the observed features.

The general circumstances of the case under consideration thus lead us again to the supposition of ground-ice; and this view is remarkably strengthened by the coincidence that this single instance of scratched boulders is found in immediate connection with the only known example of a scored and polished rock-surface. The boulder-bed is here a bottom rock, resting upon compact Pem-limestones (Lower Vindhyan). For a length of 330 yards along the river's bank this underlying rock is exposed, displaying a large surface, polished, scratched, and grooved after the fashion so familiar to glacialists. The surface has a slope of 12°—15° to the west, obliquely overcutting the strata, which have a dip of 8° to west, south-west.

* Mr. W. Blanford also gave a brief notice of the fact, and of the general evidence for the existence of glacial forces at this early geological epoch in India, at the meeting of the British Association at Bradford, 1873, Sections, p. 76.

The striæ and grooves run in long parallel lines, having directions between north-east and north-north-east, oblique to the slope of the surface; and from the manner in which the rock is affected at the edges of the few planes of jointing, it can be inferred that the movement was *up* the slope. It is, of course, not certain that the present inclination of this surface is the same as when the scoring was produced. The Tálchírs have undergone considerable crushing and displacement, though this might well have occurred in soft strata without much affecting the hard rocks against which they rest; but the actual conditions are so far confirmatory of the view we have been led to—of an ice-raft being drifted against and impelled up an opposing rock surface.

The boulder-bed itself is strongly developed in the district, especially to the north, where the contained masses of foreign rock—limestone, quartzite, granite (*pegmatite* and *protogine*) &c.—are of huge size and very numerous. In the immediate vicinity of Irai, the boulders are for the most part small, a few attaining a major diameter of 2 feet and even 2 feet 6 inches. Some of these boulders are worn smooth on certain sides only, and in the direction of the longest diameter; others more rounded have a beautifully polished surface: they are moreover striated and scored in fine parallel straight lines, precisely similar to the rock-surface above described, and resulting evidently from glacial motion or 'ground-ice.'

These boulders are enclosed in a fine gravelly bed of heterogeneous material, conglomeratic near the base, and intermingled with angular rough blocks and rock fragments.

It would appear that the freighted ice-mass had travelled a long distance from the south-west, through the Utnúr and Edlabád (Idulabad) districts, where rocks occur of the same composition as that of the several boulders.

The evidences for the glacial origin of these deposits is as conclusive as that for the ice-age formations of Europe.

The latitude of Irai is 19° 53′, elevation under 900 feet; the most southerly known position of the Tálchír boulder-bed is latitude 17° 20′, and only a little above the level of the sea.

BOMBAY,
*September*, 1874.

## TRIALS OF RÁNIGANJ FIRE-BRICKS, *by* T. W. HUGHES *and* H. B. MEDLICOTT, *Geological Survey of India.*

Amongst other investigations connected with the projects to utilize the Indian iron-ores, some fire-bricks that were furnished by the firm of Messrs. Burn and Company were examined and tested in September last.

They were made from various clays obtained in the neighbourhood of Ráníganj and elsewhere, and were highly recommended as having stood the wear and tear of ordinary cupolas, and it was hoped that they would be found capable of standing the more heavy work of a blast furnace. It will be seen, however, from the subjoined details of my experiments, that there were some defects in their composition, and that although they were quite as good, or rather somewhat superior to the Stourbridge fire-bricks which could be procured at the time, they fell short of the excellence of Glenboig.

Subsequent trials, however, of the same kind and degree as those conducted in the first instance were made by Mr. Medlicott on bricks improved as suggested in the first report, and his verdict was "that several of them stood the test perfectly, showing no sign of cracking or of vitrification." These latter trials were made in the presence of Mr. Whitelaw, Manager of the Bengal Iron Company's proposed work, and others, who agreed in the favorable estimate formed of the quality of these bricks.

The experiments were, with the kind permission of Colonel H. Hyde, R. E., Master of the Mint, conducted at the Mint furnaces.

Mr. Hughes, who conducted the first trials, reported—

1. "The fire-bricks tested by me were furnished by the firm of Messrs. Burn and Company, and are stated to have been made from fire-clay obtainable in the neighbourhood of Mallapúr.'

"The results of my experiments are—

"*1st.*—That the material from which they are made is very refractory, and capable of resisting high temperatures without sensibly fusing.

"*2nd.*—That the bricks, however, have failed to sustain the high character for excellence which Mr. Cowhan (the Manager of the Rániganj Pottery Works) has attributed to them, inasmuch as they shrink on being subjected to strong firing, and show a tendency to fissure.

"*3rd.*—That compared with Glenboig fire-bricks they are inferior; but compared with Stourbridge fire-bricks they are somewhat superior.

"I attribute the shrinkage and fissuring to the texture being too fine; and this can only be remedied by the addition of a proper amount of burnt clay in coarse powder, or some infusible substance like silica. The particles of silica (quartz) must not be too fine, otherwise they may enter into combination with the clay.

"The usual proportion of raw to burnt clay is $\frac{2}{3}$ of the former to $\frac{1}{3}$ of the latter, and I believe this proportion was adopted in the manufacture of the fire-bricks from Rániganj. It does not appear to have answered however; but this was probably due to the burnt clay having been ground up too fine. On a purely practical point of this kind, I do not like to give a decided opinion, as experience alone can determine what the proper proportions ought to be, and I would suggest that separate sample bricks be prepared, containing varying proportions of ground brick and silica, and the particles to be of varying sizes. A series of experiments carefully conducted will, I feel sure, enable fire-bricks to be made that will possess all the qualities requisite for the special purposes to which they may be applied."

*12th September* 1874.

DETAILS OF EXPERIMENTS.

(A).—The brick marked A was subjected to a temperature of over 3,000 Fahrt. in a wind furnace, the fuel being English coke. It was purposely broken in half.

*Remarks.*—The edges have stood well.

(B).—Was heated in the same furnace as a Glenboig brick, at a temperature considerably higher than the smelting point of cast-iron.

*Remarks.*—It cracked, and was fissured throughout.

(C).—Was submitted to conditions similar to (B).

*Remarks.*—It is superior to (B), but it is internally fissured. It contains an excess of alkaline earth, which has vitrified.

(D).—Was inserted in a plumbago crucible to avoid contact with the coke. This was carefully weighed and measured previous to insertion and after extraction Its tenderness was also noted.

*Remarks*.—The edges have resisted fusion, which is a good quality, and its tenderness was not of an appreciable amount. It contracted, however, more than I expected. The following were the measurements and weights :—

| | | | |
|---|---|---|---|
| Measurement before insertion | ... | $9\frac{7}{8}''$ long. | $2\frac{1}{8}''$ deep. |
| „ after extraction | ... | $9''$ „ | $2\frac{6}{16}''$ „ |
| Weight before insertion ... | ... | ... | 277 tolas. |
| „ after extraction ... | ... | ... | $275\frac{1}{2}$ „ |

This brick when externally examined appears to approach in texture much nearer the required standard than any other.

(E).—Was heated like the last in a plumbago crucible. It is made of pure fire-clay.

*Remarks*.—I think it was too strongly burnt in the first instance, *i. e.*, before it passed into my hands. It cracked on being taken out of the furnace and deposited on a cold floor.

(F).—Was tested in the same manner as (B) and (C).

*Remarks*.—Like the other bricks, it exhibits fissures internally.

(G. & H).—Glenboig bricks, purposely broken, submitted to conditions similar to (B) and (C) and (F).

*Remarks*.—It will be observed that there are no fissures. No contraction and no softening.

In the second series of trials conducted by Mr. Medlicott, ten bricks, made at the Ráníganj works, were tested with one of Stourbridge brick and one of Glenboig brick, and also one common machine-made brick. They were kept for four hours in the gas furnace in plumbago crucibles—for the last two hours at the full blast. None showed any sign of fusion. The machine-made brick and the Stourbridge brick were badly cracked, and one of the Ráníganj bricks slightly so. The loss of weight was very marked in the Glenboig brick ; next so in the Stourbridge, probably due to the coarser texture of the former, and in both to their having been less well dried than the others.

Five of the bricks were put into a coke furnace with a Glenboig brick, and five in a second furnace with a Stourbridge brick. The former furnace seems to have been most heated : even the Glenboig brick bent and broke, and showed as much vitrification as the others. In the other furnace, all were more or less damaged—the Stourbridge least so.

GEOLOGICAL MUSEUM,<br>*January* 1875.

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MAPS.

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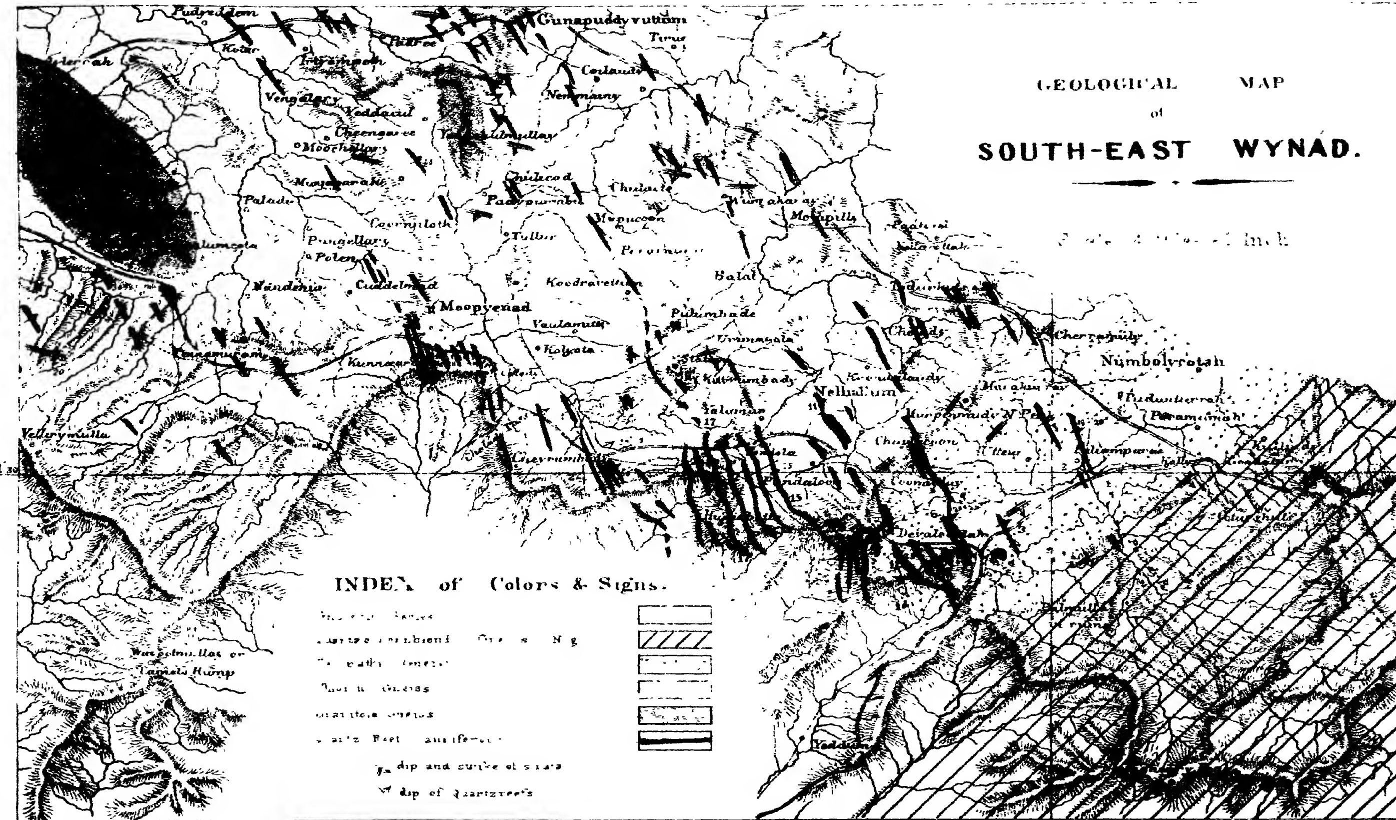
GEOLOGICAL MAP
of
SOUTH-EAST WYNAD.
INDEX of Colors & Signs.
dip and strike of strata
dip of Quartzreefs
Gunapuddyvuttum
Numbolyrotah
Moopyenad
Nelliallum
Pudyeddom
Cherrapully
76 30

# RECORDS

OF THE

# GEOLOGICAL SURVEY OF INDIA.

**Part 2.]** **1875.** **[May.**


## PRELIMINARY NOTE ON THE GOLD-FIELDS OF SOUTH-EAST WYNÁD, *Madras Presidency, by* WILLIAM KING, B. A., *Deputy Superintendent, Geological Survey of India, Madras.*

Reason for present brief report.

The attention of the Madras Government having been again called, after a lapse of nearly forty-two years, to the occurrence of gold in the Malabar District, it was considered advisable that an examination of the country should be made by the Geological Survey of India. It now, however, turns out that the area over which the auriferous deposits and quartz reefs extend is so large, that a considerable period of time must elapse before a full report of the whole district can be made. In the meanwhile, as a gold mining company had been started with the intention of opening up the quartz reefs known to exist in Wynád, and more particularly those near Dayvállah, my attention was first directed to this region. The country examined up to this time constitutes a local division of this part of the district and is sufficiently large and important in itself to be described separately in these Records.

Topography of Wynád plateau.

The intermediate elevated terrace of mountain-land lying between the low country of Malabar, the loftier plateau of the Nilgiri mountains, and the Mysore territory, called the Wynád, has been conveniently separated (principally by the Coffee Planters) into three divisions: North Wynád, South Wynád, and South-east Wynád; and these larger areas are again parcelled out after a native classification into *Amshams*. South-east Wynád includes among others the Nambalicodo, Moonád, and Moopia-nád Amshams, the latter being the most north-westerly of the three, and touching on South Wynád or that in which the central village of Vythery is situated. Manantoddy, the principal town of the plateau, is in North Wynád.

The present paper has to do with so much of South-east Wynád as lies to the south-south-west of and alongside the road from Gúdalúr to Sultan's Battery (Gunnapuddy-vuttom of Atlas-sheet). The other boundaries are the Nilgiri plateau and Ouchterlony valley on the east-south-east; the great line of precipices of the Western Ghâts from Nádgáni (Carcoor ghât) to the mountain of Vellaramulla on the south-south-west, and a high water-shed running from Vellaramulla to Sultan's Battery on the north-north-west.

Elevation.

This mountain terrace has an elevation on an average of above 3,000 feet; but out of it rise peaked ridges and hills of considerably greater heights, varying from 3,500 to nearly 7,000 feet above the sea.

Forest covering, cultivation.

Along the edge of the ghâts, occasionally for short disatnces inside of these, and down the great ribs and intermediate trenches to the low country, all the ground is covered by dense and lofty black forest. Inland, there are rounded grassy hills enclosing valleys, interspersed with good belts of forest, most of which is, however, of poorer tree jungle than that of the ghâts. Nearly all the valleys contain swampy flats, which are largely cultivated as paddy or rice-fields. The coffee gardens, which are the European specialité of Wynad, have, as a general rule, been made in clearings near the edge of the ghâts in the black forest, or in the denser parts of the inland jungle.

Climate.

A good deal of misconception appears to exist as to the healthiness of Wynád. As far as my own personal experience goes, the climate from the end of September to the middle of January is tolerably well adapted for Europeans. I am informed by the planters that it is even healthier from May to September; so that there are only three months in the year when the country is not healthy. Many planters leave during these months for the coast, or the Nilgiris; but others are known to have remained with their wives and children for two and three years continuously.

On the other hand, the climate is not suitable to the natives, except such as belong to the country, as the Chetties, Mopahs, Korumbars, Pannirs, &c.; but much of this unsuitability, may, however, be due to carelessness of the men brought into the country, and the fact of their being away from their homes.

Next to the tremendous rains of this region and the two or three unhealthy months, the land-wind is perhaps one of the worst evils to be encountered. Bungalows are built so as to present a sheltering side to it; it is dangerous to sleep in; and it is about as disagreeable to be felt or heard as the bleakest east wind in England. Fortunately, it seldom lasts all day except for a short time in the year; and in its place comes the oppositely mild and soothing wind from the western sea.

History of the gold question.

The Malabar District has been famous for gold from time immemorial. Gold is still washed for in the low country and in Wynád; and it used to be got in old days from quartz 'leaders' in the hill country around Dayvállah, Nellialum, &c. Two tribes of people obtain the gold. The *Pannirs* wash for it in the alluvium, surface soils, and river sands. The *Korumbars* dug down to and excavated the quartz leaders. Tradition says that large finds of gold have been made at odd times by the Korumbars. The Pannirs rarely find more than four annas' worth of gold in a day each man. The latter only wash for gold now (in the Wynád) in the off season, when they cannot get work in the coffee gardens at five annas a day.

In 1793 the gold mines of Malabar appear to have been noticed by the then Governor of Bombay, who tried to get information on the subject; and they were farmed by the Madras Government in 1803.

In 1831 Mr. W. Sheffield, Principal Collector of Malabar, wrote an interesting report on these gold mines, upon which Lieutenant Woodly Nicholson, 49th Regiment, Madras Native Infantry, was deputed to explore the country with a view to the development of this industry. The latter officer visited the Nambalicode Amsham, examined all the old workings of the Korumbars on the Chulaymullay near Dayvállah, and obtained gold from the surface washings in the same neighbourhood. He also visited all the known gold localities in the low country of Malabar. He does not seem to have thought much of Dayvállah, and the gold obtained was not so pure as that from the plains. His acquaintance with the practical business of the matter and his knowledge of the geological structure of the country were very poor, but his perseverance at the work was marvellous under the difficulties, real and imaginary, with which he had to contend. A committee was then appointed, consisting of Mr. F. Clementson, Principal Collector, Major A. Ross, Superintending Engineer, Malabar and Canara, and Dr. F. W. Ward; and an able report, dated 25th May, 1833, was the result. These three gentlemen practically condemned the working for gold, as an European industry, in the low country of Malabar. My own examination of the plains has as yet only been a cursory one; but without going so far as this decision, I am inclined to agree to a great extent with it, more especially as it would appear from what we now know that there is sufficient evidence to show that European energy is more likely to meet with success in the Wynád.

In 1865 or 1866 Mr. Stern (of Australian experience) paid a prospecting visit to Wynád and made trial of the alluvial deposits, of which there are several in the form of flat swampy land along the courses of the streams. He tried near Dayvállah by sinking pits to 'bottom rock' and always got gold, but not in sufficient quantity to make it worth while continuing his work.

Within the last year or so attention was again called to the occurrence of gold in the Wynád. Some of the planters had lived in Australia previous to their coffee experiences, and being more or less acquainted with quartz and its occasional associated minerals, they were naturally struck with the quartz in Wynád, while they also knew that gold was, and is, obtained by the natives. There was, however, a want of capital, and no one had seen gold in the quartz until Mr. Withers, the present Manager of the Alpha Company, came down to Wynád. Mr. Withers, who knows how to wash for gold, and is acquainted with quartz reefing, prospected the country for a long time until he felt convinced that nothing was to be done at alluvial and surface washing. He then explored the old pits and workings of the Korumbars and finally settled on a quartz reef in which he found gold visible. This reef and the ground alongside had been extensively worked in old times by the Korumbars. In one of the numerous caves he found the remains of one of these native miners, and thus the lode came to be called the "Skull Reef."

The Alpha Gold Company was then started, the prospectus of which states on the authority of "the Company's Manager and two of the Directors, who have had much experience of quartz-reef mining in Australia," that the stone will yield about one ounce of gold to the ton of quartz.

Alluvial sources of gold, not rich.

The most common mode of occurrence of gold in South-east Wynád is naturally in the Recent deposits, such as the surface soil on the hill-sides, the stream sands and gravels, or the true alluvial flats (Vayals or Veils) which are so frequent a feature in this upland as to have given it the name of the "land of swamps"; but in none of these ways does it seem that any large quantity of gold is stored up, except perhaps in the swamps which have as yet only been tried by Mr. Stern, when they were found to be as poor as the rest of the land.

From surface soils.

The surface soils are generally very thin, and they are not extensive enough to justify any large attempt at washing by hydraulic sluicing. Still they are perhaps the favorite resort of the Pannirs who can always from known patches of ground produce a certain small amount of gold. On four occasions these men worked for me at places around Dayvalláh, but they never got as much gold as would pay for their employment at five annas a day for each man. Occasionally, however, they chance on richer finds. The largest known fragment of gold found within the last few years in Wynád weighs over seven pennyweights, but it contains some quartz. It is of pale color, and is not much rolled; in fact it has evidently not been washed far from the present reef, and has thus not been subjected to that exposure and attrition which seem necessary for the production of the finally purer metal usually obtained from alluvial washings. In addition to this, a further small rolled fragment of good yellow gold without quartz, weighing nearly 11 grains, was lately found by the Pannirs of Dayvalláh; and a larger one, weighing 21·9 grains, is in the possession of Mr. H. V. Ryan of Glenrock—Mr. Minchin and Mr. Ryan have each occasionally employed coolies on their estates to wash for gold, but they do not find that the quantity obtained is sufficient to encourage any further exploration. The latter gentleman has collected 8·1 dwts. of gold, amongst which is the small nugget just mentioned. Out of this, 150·9 grains had to be collected by amalgamation and there were 21·6 grains of dust. The gold generally found by the Pannirs is in very fine dust, or in small flat spangles only collectible from the black iron-sand, finally left with them, by amalgamation in the wooden washing dish or *murriya ;* but at times there are somewhat larger pepitas. This size of the grains agrees with what I have seen of the precious metal in the matrix.

From stream sands, &c.

The stream sands are next resorted to, but they are of no extent in this part of Wynád, as there are no large reaches, or hollows in the river beds in which gold could be stored up, while, as I shall presently endeavour to show, there is not much likelihood of its being retained in them, even if it were washed down in any quantity. As it is, the usual small amount of gold is obtained here also by the washers. In both conditions of deposit, as surface soil, or as river sand, the men nearly always only scrape a few inches of stuff from the surface; they do not dig down to bottom-rock, or to any bottom-layer of compact stuff answering to pipe-clay.

Poverty of these accounted for.

It will thus be seen that a somewhat different mode of occurrence of the gold dust (not in pockets, or at the bottom of lighter and permeable materials), and system of washing adopted (surface scrapings only being sifted) exist in Wynád from what is known in Australia and California. Much of this may be attributable to the heavy denuding force of the south-west monsoon; or, in other words, a very large proportion of the ore weathered out of the quartz veins and adjacent country rock is carried down during the rains to the low country of Malabar. At such times every stream in Wynád is a rushing torrent in which no sediment is allowed to rest until it reaches the slower-flowing, wider and deeper, rivers of the plains. As the monsoon slackens, a little new auriferous soil is allowed to remain on the cleaned hill sides, and the old basins and reaches of the stream beds are again filled up with their usual accumulation of mud, sand, and gravel, and thus a small supply of gold is collected. There is no doubt that in the decreasing flow of water, gold dust and heavy iron sand must necessarily at many places settle down first in the hollows, but these are few and far between, irrespective of their being difficult of access by the natives. At any rate such places are not known or searched to any extent in Wynád; and it seems to me that the fact of the men preferring generally to wash stuff scraped from the surface of the coarsest gravel and sand banks (the very places where the drifting gold would be retarded by the rough bottom and then permitted to settle down among the stones) points directly to the transporting power of the monsoon streams. This is also borne out by the habit which the men have of going at certain intervals to places known to them as having yielded gold on previous occasions, where they do not find the accumulations of centuries of denudation, but the gatherings up of only one or two seasons.

Proper alluvial deposits.

In certain parts of Wynád, and more particularly around Sultan's Battery, or in the neighbourhood of Manantoddy, the valleys are filled in with extensive and thick alluvial deposits through which the streams almost immediately after they leave the steeper hill-sides, often pursue a long and devious course, or become lost for a time in deep and dangerous swamps. In Nambalycode and Moonád these alluvial flats are not so frequent, and they are small in extent. There are no traces anywhere of their having been searched for gold, except in so far as the patches of surface soil alongside the streams, or on the edges of the flats, where auriferous soil could gather, may have been searched by the Pannirs.

There can hardly be a doubt but that gold in some quantity must lie in these deposits, for when they were being laid down, even if the present rainfall existed, it is quite evident that the flow of water was sufficiently retarded, possibly by lakes which then occupied the places of the present flats, to allow of a great thickness of separate patches of the denuded material of Wynád being retained. It is, however, very questionable whether this amount would be sufficient to repay the washing of such places, for they are throughout the year charged with water for the greater part of their depth, and they are largely made up of very unstable materials. The cost of excavation, puddling, and pumping engines necessary to keep large works free of water would be enormous. In addition to this, it is probable that work could only be carried on in the dry season, three months of which are unhealthy for both Europeans and outside natives, particularly in these low-lying grounds.

Difficult to be worked.

The places where gold washing has been carried on in the area under description are frequent in the Nambalycode and Moonád Amshams; but there is now no tradition of such work ever having been carried on outside of these, although in Mr. Sheffield's Report of 1831 mention is made of places, such as Choolyode, purporting to be in the neighbourhood of Sultan's Battery, where indeed there are Pannirs, though these men are not skilled in the use of the washing dish. This apparently unsearched condition of the northern part of the field, and the ignorance of the Pannirs as to the use of the *murriya* would seem to indicate that there should be no expectation of finding any gold dust in that part of the country were there not the view that there was possibly always sufficient occupation for these men in the well cultivated lands of these northern Amshams, while in the Nambalycode country, &c., they were driven by the land-owners to search for gold, the land not being so well adapted for agricultural work.

No traces of gold washing in northern Amshams.

The next source of Wynád gold is the matrix or the quartz veins, and to a slight extent the rocks traversed by these; and here again the natives of Malabar have been beforehand in mining operations though only in a very small way when the enormous extent of veinstone is taken into account. These Korumbars have worked the smaller and more easily broken up veins often to a depth of 60 or 70 feet. The western slopes of many of the hills in the three *Amshams* already enumerated are burrowed like rabbit warrens with pits, often only four or five feet apart, and communicating by short galleries. Chulaymullay, one of the conspicuous headlands of the Western Ghâts near Dayvalláh, was once extensively mined in this way. Lieutenant Nicholson thus describes what he saw in April 1831: "After cutting our way for several hours in the thickest part of the jungle on the mountains, we came upon the mine in question, consisting of three shafts about five feet each in diameter, and ten from each other, forming an equilateral triangle, the deepest of them extending to about seventy feet, since a stone dropped in took four and a half seconds to reach the bottom. We soon found that this mine was not the only one, for, having penetrated as far as we possibly could through the jungle towards the summit of the mountain, we discovered no less than twenty-seven shafts all sunk in the same manner and forming a chain of triangles as before described, the disposition of which with regard to each other led me to suppose that they have all subterraneous counter-shafts communicating with each other, and probably extending to a large main shaft which I trust may be discovered on the arrival of the pioneers." The same style of work is to be

The conditions of gold in the matrix.

seen near Nádgáni Bungalow and westwards, towards Chulaymullay, near Nulliallum, and away on to Cheyrumbadi. In these places these men seem to have led water to the steeper hill slopes and got at the numerous small veins on the foot-walls of the larger reefs by regularly sluicing down the hill-side even to the extent of causing occasional landslips. In the Glenrock Estate the upper part of the great valley or *churrum* in which it is situated is all of fallen earth, and there are still evidences of large sluicings having been carried on, while the face of the ridge north of Hudiabettah is pierced all over with pits as in Chulaymullay.

Wynád generally a country of quartz reefs

According to every information that is to be obtained, the whole of Wynád appears to be traversed by quartz reefs, some of which appear in the low country of Malabar, while others are traceable into the Ouchterlony valley; and even, it is said, on to the spurs of the Koondah mountains to the south. At present it is only known certainly that they are very strong and numerous in South-east Wynád.

Auriferous reefs.

In the Nambalycode Amsham there are at least eighteen reefs, nine of which are auriferous; and the immediate neighbourhood of all has been worked by the Korumbars, or washed by the Pannirs, for gold. Most of these eighteen reefs are traceable northwards into the Moonád Amsham.

Still further westward, by Pandalur, Cheyrumbádi, and Cholády to Vellaramulla, there are at least twenty-four more reefs, those in the neighbourhood of Pandalur having had their 'foot-walls' and 'leaders' very extensively worked in old times by the Korumbars. Those of Cheyrumbádi and Cholády have not yet been sufficiently examined; but it may be here stated that one of the richest gold-washing regions (Kathaparaye) of the low country could only have been supplied with its gold from the Cholády and Vellaramulla drainage basins.

Appearance of gold from reefs and washings.

The gold obtained from the reefs is of a pale color; that from the leaders and washings is generally yellow; and that from the surface washings nearly always of a good yellow color. The natives know this difference, preferring the 'mud gold' to the 'stone gold,' which last they designate also as 'white gold.'

Fragments of stone gold are found at times by the Pannirs in their washings of surface soil; but there is nothing known of pale gold dust having ever been got in the washings.

Quality of alluvial gold.

In an assay made of some of the gold obtained by Lieutenant Nicholson in 1831, the following result is given:—

DAYVALLAH.

| | |
|---|---|
| Gold ... | 90·88 |
| Silver ... | 8·86 |
| Copper ... | ·26 |
| | 100·00 |

This was evidently gold obtained by the washers; for Nicholson does not seem to have got any reef gold.

Two samples from auriferous surface soil near Dayvalláh have been assayed by my colleague Mr. Tween, one of which, as will be seen, is very near Nicholson's specimen, while the second is richer.

| | | | | Carats. | C. grains. |
|---|---|---|---|---|---|
| No. 1, Gold | ... ... ... | 93·00 | = | 22 | 1 Fineness. |
| Silver | ... ... ... | 7·00 | = | | |
| No. 2, Gold | ... ... ... | 90·00 | = | 21 | 2¾ Fineness. |
| Silver | ... ... ... | 8·67 | = | | |

Neither of these three assays comes up to the quality of the dust obtained by Nicholson in 1831 from the Malabar low country, which varied from 94·53 to 99·22 in the percentage of pure gold.

When the matrix gold is analysed a very different result is obtained showing a considerable falling off in the fineness of the ore. There is also a much greater disparity between it and the alluvial gold than is usually displayed between the two kinds in Australia, or even in California; though the percentage of pure gold in the Wynád ore is nearly the same as in that of the latter country.

Mr. Tween has supplied me with the following assays:—

| 1. Skull Reef. | | 2. Monarch Reef. | | 3. Mixed sample. | |
|---|---|---|---|---|---|
| Gold ... | 67·07 | Gold ... | 82·69 | Gold ... | 86·86 |
| Silver ... | 32 93 | Silver ... | 11·32 | Silver ... | 10·96 |

and these according to the scale of fineness make the ore of—

| | Carats. | C. grains. | |
|---|---|---|---|
| Skull Reef . .. ... ... | 15 | 3 | Fine. |
| Monarch Reef ... ... ... ... | 19 | 2¾ | " |
| Mixed sample ... ... ... ... | 20 | 2⅝ | " |

An ounce troy of the mixed sample, taking the mint price of standard gold at £3-17-10½, would be worth £3-13-6¼, or about Rs. 36-12-2.

The sample from the Skull Reef is remarkably poor, and if it be a fair average (which I do not think it is, as I have seen gold at times in the richest part of the lode having a much better color than that of the amalgamated sample tried), it would reduce any calculation as to the return of this reef by nearly one-third. The specimen from the Monarch Reef is only from one crushing of four pounds of stone; and cannot be considered as so fair a sample of gold right across the lode which was the case with that taken from the Skull. The mixed sample is from amalgamated ore taken from six reefs; and it may be taken as an average for Wynád gold as far as it has been yet tried. It is very probable that the fineness of the gold in the different reefs will vary just as frequently as it is known to do in other auriferous countries.

Mode of occurrence of gold.

As is usual in most gold regions, the precious metal occurs here in the reefs or large lodes, in the leaders and spurs, and in the 'casing' or nondescript rock lining or casing these.

In leaders and small veins.

The ore of the leaders and casing is mostly visible, and is what is technically called 'coarse gold;' that is, it occurs as small segregations in the interstices of the quartz, or of the assembled cubical crystals of what is now limonite, or even in the interior of these cubes. It is also very often visible in the unaltered iron-pyrites which is not quite so frequently seen in the leaders as its pseudomorph limonite. A very common mineral in the casing of some of the leaders is pyrolusite, in which also the gold is often visible. The blue-black variety of pyrolusite occurs also with the gold visible at times.

It is this variety of gold which the Korumbars evidently always sought for, principally from its splendid color; then, because it is so easily seen and often obtained without the trouble of amalgamation; and lastly, because it occurs in the casing and leaders or small veins of quartz, all of which were easily broken up in the extemporized mortar holes which are still to be seen cut in adjacent blocks of gneiss or quartz, or calcined prior to pounding. The old miners seem never to have broken up the big reefs, though they 'cayoted' or dug in among the 'riders' or masses of country rock and casing enclosed or contained in the interior of the reefs.

In the reef.

The gold of the reefs or great lodes is generally 'fine gold,' or such as is disseminated through the gangue in extremely fine particles quite invisible even with the magnifier. After the quartz is crushed and washed, this fine gold may be seen on the furrows of the rude wooden dish used by the Pannirs like little painted waves of color. At times, however, the gold is visible even in the white quartz in short streaks and little angular masses; though it is more generally seen in the same form in the red and brown stained ferruginous and cellular quartz.

Appearance of reefs.

The quartz reefs are, without exception, white colored on the outcrop or when they come to 'grass'; so that it is utterly impossible to say from a surface inspection whether they shall be richly auriferous, or not. The Skull Reef of the Alpha Company which has as yet shown most gold is as white on the surface as any other of the reefs.

All the reefs are badly defined at the outcrop: they just show a few feet over the ground and never stand up as marked walls cutting across country as some quartz reefs do in other parts of this Presidency. Occasionally, they show well on the eastern slopes of the grassy hills, as when their upper surfaces or 'backs' just happen to form parts of these slopes.

Lie of reefs.

In such an undulating, or deeply denuded, country as the Wynád, it is difficult for an ordinary observer at first sight to make out the true direction of the great quartz-lodes, their dip or underlie being rather low; but when followed out for long distances they are seen to have a prevailing north-north-west, south-south-east strike or 'run' across the country. At places there may be a slight deviation from this; and for short distances there are slight curves; but, on the whole, this is the direction for South-east Wynád, and it is always across, not with, the stratification of the rock of the country. The dip is always to the eastward, generally at an angle of 25° to 30°. There is, however, a tendency in the 'underlie' to be lower on the tops of some of the hills, and to increase in the valleys. For example, the Skull Reef at the present place of quarrying dips at 20° to 25° east-south-east, while on the top of a hill a short distance to the north, some 200 feet higher, it is 10° and nearly flat. The same feature shows in the Hamsluck Reef; and the Monarch Reef, at its lowest level, has a much higher dip than on the hills.

Of the leaders.

The leaders and spurs, or side veins, strike off to the westward from the foot-walls, or undersides, of the big lodes. They dip and wave about in all directions, very often rather to the northward.

Extent of reefs.

The great ledges or reefs of quartz appear to vary much in thickness both in their length and depth, sometimes dying out, or at least becoming very thin for short distances in their length; and, as I am inclined to believe, even behaving thus in their depth. Some of the reefs are traceable with occasional breaks or thinnings-out for great distances. The Monarch Reef would seem to be traceable for about nine miles; other reefs show their outcrops at intervals for two, four, or six miles.

It is much more difficult to say anything as to their depth in the underlie. Very many show by their outcrop on the hills and valleys that they are 300 or 400 feet in depth. The Hudiabetta Reef, on the edge of the ghâts, gives indications of being 1,300 yards down its underlie; while there is slight evidence that some of the reefs west of this show down in the low country. On the other hand, two large reefs, as they run south of the Nádgáni-Gúdalúr road, are not seen in the deep trenches, and it is difficult to say whether they are covered up or have actually thinned out.

The thickest actual section is 15 feet in the quarries of the Skull Reef, though there must be greater thicknesses than this close by. A good average thickness in most of the reefs may be taken as from 4 to 9 feet. The thickness of the leaders naturally varies very much. They appear to run generally up to 2 feet or so; but there is one under the Dunbar Reef which is 6 to 8 feet in thickness.

A very common feature in the outcrop of the big 'ledges' is, that they show strong on the higher parts of the ridges and hillocks traversed by them, and thinner or not at all in the saddles. This at first sight points to a probable thinning out in depth; but there is the view that the higher ground is more open to denudation while the saddles would to some extent be covered up by débris of the country rock, and their slopes are not so steep as those of the ridges; the outcrops, too, are deceptive, for they are often encumbered with big lumps of fallen quartz. Indeed, the masses of fallen quartz are in some places so large and so tumbled together down the western slopes of the grassy hills that they give the appearance of stone *in situ*.

Rock of the country. Gneiss.

The rock of the Wynád, or as it would be termed in mining regions the 'country rock,' is gneiss, belonging to the oldest known series in India, termed variously the *Crystalline*, *Gneissic*, or the *Metamorphic series*; and is of very variable constitution in different parts of the country. Ordinarily, there is a massive foliated quartzo-felspathic, or quartzo-hornblendic variety, with intercalations of micaceous and talcose schists; but all these are, except in the hill-ridges, generally weathered or decomposed into a more or less tough clayey rock, granular and friable with the undecomposed quartz, dark red and brown from the hornblendic and chloritic constituents, or white, pale colored, and cheesy, or soapy from the felspathic, micaceous, and talcose ingredients of the original rock. There is a large quantity of ferruginous matter distributed through the gneiss in the form of minute granules or crystals of magnetic iron; and in one particular band in the Marpanmúdi ridge, as laminæ of gray hæmatite. Hence the red and brown colors of much of the decomposed rock; and also its occasional lateritoid character: while at every working of the surface soils or the river sands by the Pannirs there is the unfailing accompaniment of black iron sand.

The strike of the foliation, or indeed of the lamination and the bedding of the gneiss, is usually east-north-east, west-south-west, the dip being mostly at high angles to the southward; except in the Vellaramulla and Sultan's Battery country, when a west-north-west, east-south-east foliation is prevalent with some folding, and even reduplication of the beds.

Several bands of gneiss.

In South-east Wynád four belts of gneiss are recognizable. Along and south of the Nádgáni-Gúdalúr high road there is the northern edge of the highly syenitoid and quartzose gneiss of the Ouchterlony valley and the Nilgiris. North of this and striking about east-north-east, west-south-west, is a highly felspathic band with two minor belts of chloritic gneiss. In this, the Dayvállah zone, there is very little true massive rock until—still going north—the conspicuous and picturesque serrated and lofty ridge of Marpanmúdi and the Needle Rock is reached. Here a very hard and thick band of highly quartzose and ferruginous gneiss is met with, in which the run of the strata is rather tortuous; while there are indications of a synclinal roll in the great wall of rock crowning the ridge above old Dayvállah and in the Needle Rock. In the depression north of the Marpanmúdi range there is a wide belt of much more varied gneisses, which, on the whole, are not so felspathic as the Dayvállah band, nor so quartzose and hornblendic as that of the Ouchterlony valley. This zone is traversable to beyond the Cheyrumbádi hill station, when a further curved belt of gneiss with more schistose bands comes in as in the Vythery Cholády and Sultan's Battery country.

Two 'cores' of granitic rock.

In the country just mentioned there are two large hill masses of granitic rock; namely Yeddakulmullay near Sultan's Battery and Mumramulla or Culpetta hill nearer to Vythery. These are, as it were, great rocky cores around and over which the foliated gneisses were laid down, the great arches or undulations of which are now evidenced by the westerly dip and subsequent synclinal displayed in the Chambra, Yellambalari, and Panora peaks and the rest of the Vellaramulla range, the easterly dip of strata on the Sultan's Battery and Manantoddy side of the country; and the narrow strip of folded beds in the wall like crests of the Marpanmudi ridge near Dayvalla, south of which there is the generally southern dip of the Ouchterlony valley strata. The rock of Culpetta hill is a very rough weathering, pale flesh-colored, rather coarsely crystallized compound of quartz, felspar, and silvery mica, showing no trace of foliation. It wears away into huge rounded masses of still harder rock, giving the hill rather a resemblance to those of the Mysore country in which the gneiss is often highly granitoid. Yeddakulmullay is made up of a much finer textured rock of quartz and felspar, and minute particles of black and greenish mica, which when weathered looks very like a coarse buff sandstone. On the western flanks of the mass, the rock is rather laminated or foliated. With both these cores of granite there is a decrease in the number and thickness of the quartz veins; but these appear again quite strongly to the northwards crossing the Sultan's Battery—Culpetta road.

Hardly any intrusive rocks in South-east Wynád.

Otherwise, the country is remarkable for the non-occurrence of any strictly intrusive rocks except in a very small way. There is a dyke of hard, compact dark-green diorite seen for a very short distance in the Hamsluck estate to the west of Dayvállah. The width of this dyke is about 35 feet; and it is striking east by north, west by south, nearly vertical. It cuts off the northern end of Hamsluck Reef. A few small largely crystallized granite veins occur here and there over the Dayvállah band of felspathic gneiss, as near the dyke just mentioned and around Gúdalúr. Large flakes of mica from these are common on the Nádgáni-Gúdalúr road.

Quartz reefs become granitic.

In connexion with this rare occurrence of granite veins it may be noticed that the quartz reefs of Cheyrumbadi are in some cases charged with assemblages of large plates of mica of 2 to 3 inches in diameter; and there thus seems to be a tendency in the western veins to become granitic rather than simple quartz lodes. Likewise from Cheyrumbadi the quartz of the reefs is becoming rather granular and saccharoid.

Variation in country rock does not affect reefs or their contents much.

Sufficient data have not yet been gathered to be able to write with any confidence as to how the quartz reefs may have been affected by the different belts of gneiss in which they were deposited. The ledges certainly seem to show stronger in the Dayvállah belt. They nip out very thin, and even disappear in the hard Marpanmúdi range; but they come to grass again to the north of this. There are perhaps not so many reefs to the north of the Marpanmúdi range as to the south of it. The occurrence of gold in the leaders does not seem to have been affected one way or other on either side of this ridge, for the old Korumbar works are as frequent about Nellialum and Pandalur as on the Dayvállah side.

The quartz reefs which have been traced out, or are sufficiently marked, are as follows commencing from the Gúdalúr side of the country, where and eastward of which there do not appear to be any ledges, auriferous or otherwise, for some miles at least:—

Enumeration of quartz reefs.

| Name of Reef. | Character. | Average proportion of gold. | Lowest proportions | | Highest proportion. |
|---|---|---|---|---|---|
| 1. Eastern ... ... | Worked on foot-wall ... | ..... | ... | ... | ... |
| 2. Paliampara .. ... | Ditto ... | ...... | .. | ... | ... |
| 3. Bear ... ... ... | ...... | ...... | | ... | ... |
| 4. Nádgáni ... .. | Worked on foot-wall ... | ...... | ... | ... | ... |
| 5. Monarch ... | Auriferous .. | ...... | ½ dwt.... | 2 dwt.... | 69. 19 dwt. |
| 6. Hamlin ... ... | Worked on foot-wall ... | ..... | ... | ... | ... |
| 7. Un-named ... ... | Ditto ... | ...... | ... | ... | ... |
| 8. Korumbar ... ... | Auriferous . | 4 dwt. to ton | ½ dwt.... | 7½ dwt.... | 180 dwt. |
| 9. Un-named ... ... | Worked on foot-wall ... | ...... | .. | .. | ... |
| 10. Cavern ... ... | Auriferous ... | ...... | ... | ... | . |
| 11. Skull .. ... | Ditto ... ... | 11 dwt. to ton | 2 dwt. | 25 dwt.... | .. |
| 12. Hamsluck .. | Ditto ... ... | 3 dwt. to ton | 1 dwt... | 7 dwt.... | .. |
| 13. Hamsluck, middle .. | Ditto . ... | 10 dwt. to ton | 8 dwt.... | 12 dwt.... | ... |
| 14. Hamslade Waterfall ... | Ditto . ... | 11 dwt. to ton | 3 dwt.... | 19 dwt. .. | 60 dwt. |
| 15. Balcarras ... ... | Ditto ... ... | 3 dwt. to ton | ½ dwt. . | ... | ... |
| 16. Puntaloor ... ... | Worked on foot-wall ... | ...... | ... | .. | ... |
| 17. Hudiabettah ... .. | Auriferous ... | ...... | | ... | ... |
| 18. Glenrock ... ... | Worked on foot-wall ... | ...... | ... | ... | . |

By 'auriferous on the foot wall,' it is to be understood that the foot-wall of the reef and the side veins therefrom have been dug at by the Korumbars, and that they are reported by the natives to have given gold. In these cases, I think tradition may be believed to a large extent.

Details of auriferous reefs.

The *Monarch Reef* is, as stated above, traceable for about nine miles from the western side of the bridge below the Nádgáni Bungalow, across the Dayvállah road (about a quarter of a mile east of the toll bar), up the long grassy ridge to the summit of a lofty cross-ridge overlooking old Dayvállah; and on to the wide gap in the Marpanmúdi range, down through the Dingley Dell Estate, and on past Koontalaudy towards the Gúdalúr—Sultan's Battery road. At its southern end a drive was put through this reef, where it was found to be 4 feet thick; but I am inclined to think that this is only part of the reef, a 'rider' or large enclosed piece of the country rock having been met with. The varied results given in the table from this reef are accounted for in this way: At first, color of gold was got in the samples taken from the drive sufficient to warrant the expectation of about 2 dwts. of gold to the ton of quartz. Subsequently, a fragment of stone from the surface, weighing 3 lbs., was crushed and 2·3 grains of gold obtained, which is in the proportion of 69·19 pennyweights to the ton. Stone, in fragments of which gold was clearly visible, was then taken from the same place and 350 lbs. of it subjected to rough crushing in a stamper belonging to Mr. J. W. Minchin, and passed over a large blanket cradle, but the outturn was extremely disappointing, as only about 3 grains of gold were got, and yet more than this had been seen before the stone was pounded up. It was soon found, however, from subsequent experiments, that the gold must have been lost in the stamping box which was merely a planked structure round the stamp-head, and as no more trials could then be made on this reef, an average result has not been entered in the table.

The quartz of the Monarch Reef is generally a milky-white coarse-textured rather glassy-lustred compact rock. At times it is stained brown or red along the fractures, and shows thin sheets and seams of brown iron rust. Flakes of bright golden colored mica are frequent; and there are rare seams of greenish talc and chlorite. White iron-pyrites occurs at rare intervals. The quartz is rudely laminated with the lie of the reef, and spurs of talcose schist are frequently running into the body of the lode. The casing is partly of talcose schist, with frequent laminæ of pyrolusite. This description applies to so much as is exposed in the drive or cross-cut.

The foot wall and leaders of this great reef have been extensively worked on the slope of the ridge overlooking the old Dayvállah valley in Mr. Hughes' clearing, and in the valley itself.

*Korumbar Reef and others.*—Between the Hamlin and Skull Reef, there are at least five lodes, but they are only traceable at intervals to the district road. One, called after the native miners who pointed it out, gave another set of curious returns, which will illustrate the faulty condition of the extemporized crushing apparatus with which work had to be done.

Seven pounds of stone from the Korumbar Reef were hand-pounded and gave 12·40 grains of good yellow gold; and a further crushing of the tailings of white iron-pyrites, of which there was a large quantity, added ·40 grains to this; being in the proportion of 8 oz. 10 dwt. 16 grains to the ton. One hundred and sixty pounds of this stone were then pounded, and all but 10 lbs. crushed and passed over the cradle, when gold at the rate of half a pennyweight to the ton was got. But from the 10 lbs. remaining which was hand-crushed there was gold at the rate of $7\frac{1}{2}$ dwts. to the ton. In the meantime, another sample of 4 lbs. of stone was brought in from a new reef (Hamslade Waterfall) which gave 7 grains of gold, I then went to this reef with the men and quarried out about 70 lbs. of stone which was divided for separate trial by wet crushing and by hand work, when the following outturn appeared :—

| | | | | |
|---|---|---|---|---|
| 30 lbs. hand work | ... | ... | ... | 6·3 grains of gold. |
| 40 lbs. wet crushing | ... | ... | ... | 1·3 ,, of ,, |

The latter sample showed more gold than this in the uncrushed stone. Even if the wet-crushed result be true, the proportion for this reef is 10·19 pennyweights. It was evident, however, that gold had been lost in the stamping box; had indeed possibly never left it, for the bed plate (fixed) could not be completely boxed in.

The outcrops of these reefs are very short for any continuous distance, but there can be little doubt that they will be found continuing northwards nearly up to the Marpanmúdi ridge; and some of them show down in the Nádgáni estate in the Carcoor *cherrum*. They are thin, about 3 to 4 feet on the edge of the *cherrum*, and look at other points as though they kept to this. Their appearance is very favorable, being more or less colored with oxide of iron, laminated, and full of white iron-pyrites; and they show gold at times; in fact, they are just as promising-looking except in the matter of size as the reef to be noticed next.

The *Skull Reef.*—The outcrop of this lode is traceable nearly continuously for about seven furlongs, but it is in all probability connected with other outcrops of quartz to a complete length of at least four miles. Only a small part of the southern end of this reef has been taken up by the Alpha Company. At the southern end it commences on the edge of the Western Ghâts, a little more than a mile and a half due west of the Nádgáni Bungalow, on the rounded grassy knolls of this part of the Dayvállah country. Thence it runs up to the top of a high hill overlooking Dayvállah and down to the road a short distance east of the bazar. Strong leaders from its foot-wall cross the road nearer the village and run through the wooded hillock on which the old fort is situated. Its next appearance is in a high ridge on which the Roman Catholic Chapel is built, and again in the Harewood and Kintail Estate east of Mr. Hamlin's bungalow. Beyond the cross range of Marpanmúdi, it again shows in the bottom of the Strathern Estate: and still further northward in the Nallialum country.

The direction of the vein is, as usual with these south-east Wynád lodes, *viz.*, north-north-west, south-south-east, with a dip or underlie varying from 10° to 25° east-south-east. On the top of the hill overlooking Dayvállah the angle is low, in fact becoming flat, but it increases as the reef descends, being at the quarries about 20° to 25°. At the place of quarrying there is a large irregular surface of the vein exposed on the eastern slope of a grassy spur of the hills. This is full of caverns excavated by the old native miners who evidently scraped and dug at every bit of casing, enclosed country rock, and the leaders. The Manager of the Alpha Company is at present quarrying in at this exposed surface, and preparing stone in readiness for the crushing machinery which is to arrive in a few months from Australia. At the quarry the reef is about 15 feet thick, of rudely laminated quartz; laminations with the dip and strike. The back or upper surface of the lode is of coarse white quartz. From this, as was seen by a cross-cut through the reef, the rock becomes more and more ferruginous and stained of dark brown, black, and reddish colors, cellular or mouse-eaten, and charged at times with white iron pyrites much of which is decomposed, sulphate of iron and even traces of sulphur being left behind. At about 12 feet the quartz is more highly colored, very ferruginous, very cavernous, and gold is often visible in minute strings and masses. The quantity of rock worked out has not been sufficient to show whether there is any definite 'gold streak' in this lode.

Through the kindness of the Directors of this Company and their Manager, Mr. Withers, I have been supplied with a fair set of specimens from this cross-cut, which have been crushed, washed, and amalgamated in a rough manner. Very good color of gold was got in nearly every dish of pounded stone; but the results from amalgamation were very poor at first. The enormous quantity of iron pyrites associated with the gold came in the way of amalgamation, causing the mercury to granulate and become coated with the iron, sulphide; in fact 'flouing' (Australian term) set in.

I have not been able, owing to the difficulties in the way of crushing, failure of some experiments, and a want of time, to obtain a complete series of specimens and results from one cross-cut in this reef, much less from different parts of the lode, which would, of course, be the fairest way of testing the quartz, but such as have been got are now given—

| Specimen of quartz. | Weight. | Appearance, color, &c. | Results. | Depth in cross-cut from 'back' of reef. |
|---|---|---|---|---|
| 1 | 20 lbs. | Compact, coarse texture, laminated; white color ... | 2 dwts. to ton | 1st foot. |
| 2 | 28 lbs. | Still white in color, but stained with ferruginous matter | 2·5 dwts. to ton | 3rd foot. |
| 3 | .... | Whitish, more discolored with iron ... ... | None. | 5th foot. |
| 4 | 30 lbs. | Ditto ditto ditto ... ... | Good color in dish: lost in amalgamation. | 7th foot. |
| 5 | 18 lbs. | Still white, but ferruginous ... ... ... | 5·18 dwts. to ton | 10th foot. |
| 6 | 18 lbs. | Highly colored, red and brown, ferruginous, cellular, with white iron pyrites. Gold visible... .. | 19·44 dwts. to ton | 12th foot. |
| 7 | 18 lbs. | Ditto ditto ditto washed and amalgamated in my presence by Mr. Withers. Gold not visible ... ... ... ... | 25·92 dwts. to ton | 13th foot. |

For this cross-cut there is therefore an average result of 11 dwts. to the ton. At this point the richest part of the reef is a band of the laminated quartz about two feet thick within a couple of feet of the footwall or underside of the reef. The average of this rich band is 22·68 dwts.

Mr. Withers informs us that he has got almost as good results out of a shaft and cross tunnel which he made at the southern end of the outcrop, but that the reef is there narrower, about 9 feet in thickness.

*Hamsluck Reef.*—About half a mile west of the high hill-outcrop of the Alpha Company's Reef overlooking Dayvállah village there is another strong lode cropping up in Mr. J. W. Minchin's estate of Hamsluck. The lowest part of this reef, or what is seen in the bottom of the valley at its foot, is about three furlongs in length; and from this as base the reef slopes up the eastern side of a hill about 300 feet high. The strike of the reef is about the same as in others: the dip being about 20° to the eastward, though it is at a much lower angle on the summit of the hill. The known thickness of this reef is from 4 to 8 feet. The lode is cut off to the north by the dyke of green stone already noticed. It is traceable southwards into the Chullaymullay mountain, and probably runs under the northern end of Perseverance Estate. The eastern slope of the Chullaymullay alongside the latter estate has been perfectly riddled by the pits and excavations of the old miners who evidently worked at the side veins on the underside of the lode. Small samples of quartz were crushed, and gold was always got showing clear in every dishful of stuff; but the result was small owing most probably to the presence of a great quantity of iron sulphide. Subsequent crushings gave the proportions shewn in the table.

*Dunbar and Balcarras Reefs.*—About two miles further west, but on the northern side of the deep trench leading to the low country by Carambat, there is a good outcrop of a reef about 4 feet thick in the Dunbar Estate. Mr. Powell, the Superintendent of this garden, when down showing me the reef, was successful in knocking out pieces of quartz in which small streaks of gold were visible. The underside of this lode is very like in color and contents to that of the Alpha Company, the richer seam in the quartz being on this side. Leaders are numerous and large. The casing is of talcose schist, and seamed with ferruginous and manganese streaks.

The lode is traceable northwards into the Balcarras Estate, where there is a great show of white quartz on the eastern slope of one of the low hills. This part of the reef has been very extensively riddled by the old miners. In fact, all its extension northwards towards Pandalúr has been washed, and its immediate neighbourhood on the underside is still a favorite locality for washing during the rainy season. It runs through the Elizabeth and Sandhurst Estates, and close alongside the Caroline and Mr. Holmes' application, and thence northwards.

Prospects of Wynád up to date.

My observations so far appear to show that quartz-crushing should be a success, in the Nambaly-code Amsham at any rate. Here, there are eighteen reefs which are more or less auriferous in themselves, or as to their leaders. The leaders and underside of these are all known, or reported, to be auriferous with coarse gold; and it is probable that the great reason they are not worked now is that the pits necessary to be dug by the Korumbars would be too deep for their style of work, water being the great obstacle likely to be met with. The big reefs were not worked by these men on account of the difficulty of breaking up the stone, and because the gold is distributed too finely through it to have paid hand labor. With machinery and modern appliances, the reefs should pay even if only 3 dwts. of gold are got always from the ton of quartz.

The average proportion of gold for fifteen trials on different reefs is at the rate of seven pennyweights to the ton; and it is almost certain, that many of these would have given a better outturn, could more perfect crushing apparatus have been used at the time.

The fineness or touch of the ore is inferior to that of Australia, but it compares favorably with Californian reef gold. The percentage of 86·86 is given above as a fair average, for on looking at the differences between alluvial and matrix gold in other regions, it is found that they agree very closely with the difference between this sample and the alluvial ore of the upland; while the assays of the Skull reef, and the upland and low country washings do not exhibit any gradation consistent with the amount of exposure to which the two alluvial golds must have been subjected.

In Australia these ratios are as follows:—

| | | | Percentage of pure gold. |
|---|---|---|---|
| Alluvial gold ... ... ... | 23 | $1\frac{4}{8}$ ... ... | 97·500 |
| Matrix gold ... ... ... | 22 | $0\frac{7}{8}$ ... ... | 92·875 |
| Difference ... | 1 | $0\frac{5}{8}$ ... ... | 4·625 |

Californian tables give about the same difference, but the fineness of the gold is much lower, *viz.*, 21 c. 0 cg. or 88·00.

The Wynád experiments give—

| | | | Percentage of pure gold. |
|---|---|---|---|
| Alluvial ... ... ... | 21 | $3\frac{7}{8}$ ... ... | 91·95 |
| Matrix ... ... ... | 20 | $2\frac{6}{8}$ ... ... | 86·86 |
| Difference ... | 1 | $1\frac{1}{8}$ ... ... | 5·09 |

This close approach of differences for the three countries implies also that a richer gold than this is not to be expected from the reefs; though it must not be forgotten, as already stated, that the ore from the small veins and leaders is evidently superior.

The reefs are easily got at, the gneiss traversed by them being often wonderfully decomposed almost to any reasonable depth. For a long time there may be no necessity for deep sinking, as a large quantity of stone is held in the many rounded hills so common over the country, and thus little trouble is to be anticipated in getting rid of water in the mines when drives can always be made at low levels. The very prevalent idea that the gangue must necessarily be richer the deeper it is searched, will doubtless be brought to bear on any mining which may be carried out; but the safer plan in a preliminary opening up of a country like this will be to work at what will pay, rather than venture to mine ground requiring expensive pumping apparatus, in which there is—after all that has been written on the subject—no absolute knowledge that there must be more gold. It is worthy of notice that the present surface of Wynad has probably only been exposed after a slow wearing away of over 2,000 feet of superincumbent gneiss which was once continuous between the Nilgiri mountains and the Vellaramulla range, in which also these quartz veins may have been continued in their upward hade to the westward; and supposing that reefs become richer in depth, then the richness now got of 7 pennyweights, by denudation of 2,000 feet, is not any great increase on whatever may have been the state of things at the then higher outcrop; while, if the same ratio of increase is to be counted on, any further considerable increment of gold can only be expected at a greater depth than is likely to be reached on the plateau. A reasonable view is that the occurrence of rich streaks of gold will be exceedingly variable; while the prevalence of very fine gold dust in Malabar indicates that fine gold is perhaps most evenly distributed through the matrix, and therefore that beyond the first fifty feet, to which depth weathering may be supposed to extend, the return shall be tolerably constant.

The working of the mines may possibly not be as cheaply done as the present rate of wages in Wynád would lead one to expect. The coolies employed on the coffee estates get from 4 to 5 annas a day per man; but there is a decided scarcity of labor, and thus a higher rate must follow if the quartz reefs are to be worked. A further addition will be in the employment of a small number of skilled European or Australian workmen in the handling of machinery, and in directing the getting out of the largest quantity of stone, and timbering up. Still, with these additions, the labor in Wynád may be expected to be always cheaper than in other gold countries.

Great facilities towards the crushing of the stone are presented in the way of water-power, which might in some cases be obtained direct from perennial streams with sufficient fall for any ordinary wheel; or it might in most other instances be led or stored up without much difficulty or expense. The stampers, &c., of the Alpha Mining Company are to be driven by steam; but there would have been no difficulty in applying water-power at the site of their works.

Having then the presumable average proportion of gold in the stone, the value of the gold obtained so far, and the quality of the labor to be employed in getting it out, an estimate can be made of the possible paying capabilities of the Wynád reefs from the statistics of the cost of extracting gold in Australia, where the labor is manifestly much more costly than it can be in Wynád.

In Mr. Brough Smyth's "Gold Fields and Mineral Districts of Victoria" the following returns are given of the cost of complete extraction of the ore from a ton of stone:—

| | £ | s. | d. |
|---|---|---|---|
| *Ballaarat District* ... ... ... ... | 0 | 8 | 8½ |
| *Clunes* ... ... ... ... | 1 | 0 | 3 |
| *Bright* ... ... ... ... | 0 | 4 | 4 |
| Wood's Point ... ... .. ... | 0 | 11 | 6 |
| Sandhurst ... .. ... ... | 0 | 11 | 8 |
| Maryborough ... ... ... ... | 1 | 9 | 8 |
| Castlemaine ... ... ... ... | 0 | 11 | 5½ |
| Maldon .. ... .. ... | 2 | 1 | 8½ |

Some of these rates are very high and paid on stone got from a good depth in places ill-situated as to supplies of wood and water, so that the average of 17*s.* 4¾*d.* is far beyond any expected estimate of this kind in Wynád.

The value of Wynád reef gold, when compared with the mint standard of £3 17*s.* 10½*d.* is about Rs. 36-12-2 per ounce, troy, which is, of course, somewhat lower than the mercantile rate. Seven pennyweights, or the outturn of 1 ton of stone, would then be worth Rs. 12-13-10, which would leave a balance of Rs. 4-2-8 on every ton crushed, even if the high Australian rate were ever attained.

The country must now be tried cautiously, while better or worse results may in the meanwhile be obtained from experiments which are being carried out, even before the arrival of the machinery of the pioneer Company now waiting to venture in the field. There is no promise like that of the Australian or American gold-fields; no great nuggets have been found; the washings have always been poor, though there is a small supply of gold swept down the hill sides every year from the wear and tear of the quartz ledges, and the areas over which they can be applied are very small; and the gold which has been seen in the reefs is only in minute strings and grains. The ground can only be worked out by capital, the most perfect machinery, and skilled hands to guide the cheaper labor of the country in getting out the stone in the safest and readiest manner. And naturally, where the percentage of gold in the quartz is as yet so small, everything will depend on getting out a sufficient tonnage of stone in a given time.

Until more is known of the gold-producing powers of the Wynád, no better guidance can be given than the following by Mr. A. R. C. Selwyn, Director General, Geological Survey of Canada:* "It should not be forgotten that the most favorable indications are not always reliable, and the sanguine prognostications they so frequently give rise to are not borne out by the result of actual working; wherefore I should, even under the most favorable circumstances, not advise any one to invest in such enterprises to an amount beyond what he can afford to lose without serious embarrassment."

**Land tenure in Wynád.**

Hitherto the land in Wynád has been principally parcelled out in coffee gardens, either free-hold, or paying an annual rent to the Rajahs who hold a great quantity of the ground, or direct to Government. At the same time, after a certain period, a revenue is derived from all the gardens by the Government, whether it be Rajah's land, or not. Now that gold mining is likely to become an industry, a new set of land interests are being developed. The Rajahs, of course, retain their right to all minerals and can sell these as they like. The Government of Madras has not yet, I believe, decided as to how they are to act in the matter, except that applications for land for gold-mining and for agricultural purposes on which quartz reefs are supposed to exist, are being reserved for consideration until the question of mining interest is settled.

In the meantime the Rajah of Nellambor has (according to their prospectus) leased a block of 15 acres of land near Dayvállah to the projectors of the Alpha Gold Company for twelve years at an annual rent of Rs. 225. Since then it is reported that the Rajah in recent applications demands 10 per cent. on the out-turn of any gold-mining which may be carried on; and it is very probable he may change this rate. Nearly all the land in the Nambalycode Amsham is owned by the Rajah of Nellambor. Equally, as with the revenue derived from estates on Rajah's lands, it may be found advisable that the gold from these reefs should pay a royalty to Government.

In conclusion, I have to tender my thanks to all the planters whom I have yet met in Wynád for their great kindness and hospitality, and for their assistance in every way. Also for the readiness displayed by the Directors and the Manager of the Alpha Gold Company in allowing me to examine their quarry and giving me such specimens as were required. To Mr. J. W. Minchin of Dayvállah the greatest debt is due for having allowed all the specimens to be crushed at his extemporized stamper and subsequently manipulated by his Pannirs and Korumbars.

* Notes and Observations on the Gold Fields of Quebec and Nova Scotia

GEOLOGICAL NOTES ON THE KHAREEAN HILLS IN THE UPPER PUNJAB, *by* A. B. WYNNE, F.G.S., *Geological Survey of India.*

The Khareean* hills are perhaps better known, to the natives of the country at least, by the name of Pubbí, which seems to have an application to their low but broken forms. They are situated in the Upper Punjab, seven or eight miles southward of the river Jhilam, and station of the same name, forming the southern of the three minor chains which link, as it were, but without absolute continuity, the salt range to the Western Himalayan mountains.

These Pubbí hills extend from near the battle-field of Chílíanwala, and closer to the banks of the Jhilam, in an east-north-easterly direction for about twenty-eight miles in the direction of Bhimber (in Kashmere territory), but sink into a sandy nallah about four miles short of that town. They form throughout a low rugged chain, cut into by numerous ravines, having a general width of three or four miles, and a summit elevation of some 4 to 500 feet above the plains of the Jhilam and the more extensive ones of the Goojrát district.

Their culminating point is towards the western end of the range, and their declination eastwards is very gradual. In the latter direction they are crossed by the grand trunk road from Calcutta to Peshawur and by the Northern State Railway in progress of construction.

The aspect of the hills is monotonously arid, barren and rugged, presenting everywhere steep or precipitous descents into dry sandy nullahs. Towards the eastward, the 'Pubbís' are further apart, and scattered cultivated patches occur between the hills, which are separated by that peculiar labyrinth of ravines known in this country and the Pot'war as '*khuddera.*'†

The hills are composed of an enormous accumulation of sandstones, sands, conglomerates and clays belonging to the upper part of the tertiary rocks of the Northern Punjab.

From their position it was thought probable that here the Sivalik sub-division of these rocks might be developed, and their relations to the underlying beds discovered if the same marked unconformity, as occurs in other places, existed. On examination no trace of unconformity within these hills has been found, and though the soft and friable nature of most of the strata would answer well enough for the description of Sivalik rocks in other regions, their whole character suggests their identity with the uppermost deposits of the Pot'war to the north, similar clays and sandstones there having been always found to pass regularly downwards into the lower and older portion of the series, so far as has been gathered from observations hitherto made.

The arrangement of the Pubbí rocks is simple; they form a distinct anticlinal, the axis of which coincides with the higher parts of the range, a downward inclination of this at either end bringing at least a portion of the beds round to form the opposite sides of the hills. With the general form described there are many undulations of the rocks in bold

* The word is pronounced by the natives Kháree-in, and the famous battle-field of Chílianwala they speak of as Chelíanmojeearrí.

† As characteristics of these Pubbí hills it may be mentioned that the chief obstacles to pedestrian progress, besides the innumerable khuds and ravines, are the difficulty of obtaining foothold on steeply sloping clay surfaces covered with small pebbles, sandstone fragments or nodules of kunkur which slide under the feet, the insecure nature of vertically weathered parts of the soft sandstones and clays, and the trying strain in the dry sandy beds of nalahs.

A striking feature of the ground is the contrast between its dryness and the abundant evidence of abrasion by water.

Although now so dry and barren, these hills were once populous and even thickly inhabited, as is evident from the very numerous large village ruins scattered over them, and the size of some of the graveyards belonging to these villages,—fast yielding to the atmospheric erosion which frequently exposes the graves, showing that the potsherds left by the inhabitants were more lasting than their bones.

Other relics of a perhaps still older period are brick blocks of large size, though the buildings formed of these have all but disappeared.

confluent curves; they sometimes assume horizontal positions, sometimes dip steeply into the plains, but never present any high opposing dips to the general anticlinal conformation. The highest point of longitudinal curvature of the axis upwards coincides with the summit of the hills at Koar Great Trigonometrical Station, east-south-east of the village of that name and some eight miles westward of the trunk road. From this point the beds both slope to the ends of the range and curve downwards upon its sides. Here, therefore, in the bottom of the ravines the oldest rocks of the exposure ought to occur.

These are drab-brown and slightly pink or purplish red clays alternating with zones of coarse friable gray or greenish speckled sandstone formed of comminuted waste of granitic or crystalline rocks, grains of quartz, felspar, hornblende (or such a mineral) and spangles of mica. Layers and runs or scattered pebbles of hard crystalline rocks are not uncommon, increasing in quantity as the section ascends, with a predominance of white quartzite fragments well worn, until on the flanks of the hills these pebbles of larger size and in greater numbers, including a few of hill-nummulitic limestones in many places thickly sheet the ground, pointing to the local destruction of loose conglomeratic pebble beds, which, from their friable nature, are seldom found *in situ*. The various and repeatedly alternating zones of clays and sandstones are often thick, ranging from 6 to 30 feet or upwards. In eastern parts of the range the clays are more developed, deep khuds often showing little else than zones of thick purple clay, each band purple below and of a bright ferruginous yellow above, while the intercalated sandstone bands are by no means prominent, save where they form caps to the hills or hard ledges defining the outlines of the ground in a widely extended and multitudinous series of scarped out-crops.

Through the whole of the sandstones, but rarely (if ever) in the clays, teeth and fragments of large bones are thinly scattered. The beds may be searched for long distances without finding anything more than an obscure fragment broken before becoming embedded, yet in the debris between sandstone out-crops the fragments are more numerous, though seldom sufficiently perfect to be worth removal. These fragments have not been found in the clays, yet some dark liver-coloured bones seem to have come from the purple portions of these. Fossil wood has not been met with. The bones are usually whitish or buff, the teeth too hard to be touched by a knife, the bones often softer and calcareous, while some huge tusks are replaced chiefly by a pinkish white soft marly looking brittle clay or earth.

The state of fossilization exactly resembles that of the Lehrí bones thought by Mr. Theobald to be of Nahun age (see Records, Geological Survey, No. 3, 1874).

The remains found in the above described beds include parts of large bones, such as the humerus, scapula, jaws, teeth and tusks of huge pachyderms. One of the former had a girth of 2 feet 7 inches, and fragments of a pair of tusks measured 12 feet in the aggregate with a girth of 2 feet in places. Large molar teeth resembling those of ruminants also occur, with some smaller teeth; portions of joints of less sizeable, leg bones, vertebræ, fragments of large deciduous, deer horns nearly as thick at the attachment as a man's wrist, many mammalian rib bones, numerous unrecognisable fragments, and one small piece of the armature of a tortoise (?) none of which have as yet undergone comparison or determination.

From the general aspect of the rocks no hesitation would be felt in referring them to the upper portion of the Pot'war tertiary series, but it remains to be seen if the fossils will give any support to the idea that they may be newer, or that these and some upper beds of the Pot'war may both be Sivalik.

Perhaps the only feature which relieves the stratigraphical monotony of these beds is an indication of a slow transition upwards into strata even more incoherent and more recent looking than those of the mass of the hills. These upper and outer beds are coarse sandy gravelly and conglomeratic layers with drab or yellow clays containing kunkur (as indeed do many of the clays lower in the series). These clays are of the same color, and present but little difference from the alluvium of the neighbouring plains, while the sandstones and gravelly beds or base of conglomerates are of a duller and more muddy aspect than the clean gray sandstones beneath. In the sandstone or gravelly parts of these rocks an occasional rolled bone fragment or broken tooth may be found, and in some of the conglomerates pebbles of the tertiary sandstones themselves occur; but notwithstanding the derivative aspect of the bones and of the last-mentioned pebbles, the containing rocks present no visible unconformity to the beds on which they rest. On the contrary, as stated, the transition to the softer and more recent looking layers appears to be gradual, while the dips are conformable and the newer beds are found all round the elongated oval formed by the hills.

Limits to these upper beds can only be approximately and arbitrarily assigned, but they may have a usual thickness of from 200 to over 400 feet.

The thickness of the whole Pubbí series must also be estimated with caution. For 18 or 20 miles from the eastern end of the exposure, a continuous succession of layers coming out from beneath each other may be traced, all lying at low but very perceptible inclinations which would, even at angles less than 5°, give a large total depth. When the cross-section, however, is considered, between 2,500 and 3,000 feet would seem a sufficient estimate for them all, and the probability is that the amount may exceed rather than fall within 3,000 feet.

Outside the inclined newer light colored layers the alluvium of the plains may be found horizontally abutting against and resting upon these rocks. It is of the common drab argillaceous or somewhat sandy, and occasionally kunkery or otherwise calcareous character, the only traces of fossils observed in it being small, white, dead Bulimus shells and part of the skull of some large bovine animal (perhaps a buffaloe) of recent appearance, but buried beneath from 8 to 10 or 15 feet of clay and exposed in the bank of a nullah. In neither case can these indications be taken as contemporaneous with the alluvium itself, for in so easily shifted and shifting a deposit, organisms of even more recent age might readily become enclosed. Much of the eastern part of the broken Pubbí country is formed of the deeply ravined alluvium.

It is to be hoped that the fossils collected, few, imperfect and fragmentary though they be, may afford sufficient evidence to relegate these Pubbí tertiary rocks to their proper place. Pending the examination of these fossils, the only conjecture that can be hazarded, based upon structural and petrological grounds, as well as Mr. Theobald's paper previously referred to, is that the fossiliferous portion of the Pubbí rocks is probably of Nahun age, while the age of the uppermost and more recent looking layers remains an open question.

CAMP, *November* 1874. A. B. WYNNE, *Geological Survey.*

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*The following is a rough list of the fossils collected by Mr. Wynne during his examination of this small range of hills, drawn up by Mr. R. Lydekker, Geological Survey of India.*

1.—*Equus sivalensis*, from north-west of Sundpúr.

(*a*). 2nd premolar, right ramus of mandible.

(*b*). Molar and parts of mandible.

(*c*). First molar, Maxilla.

2.—*Equus sivalensis*, from near Changas, Pubbí hills—distal extremity, right metacarpus.

3.—*Bos*, Purr Kuss, inside of stream, in bank 8 to 10 feet below surface,—part of maxilla of left side, containing 1, 2 and 3 premolars, and first molar.

4.—*Bos*, near Changas, Pubbí hills—

(*a*). 2nd molar, right ramus of mandible,

(*b*). Fragments of molars.

5.—*Bos*, near Changas, Pubbí hills,—3rd molar, left maxilla.

6.—*Bos*, north-west of Sundpúr or Sandepúra,—distal extremity, right metacarpus.

7.—*Bos*, from Gotriala to Besa,—fragmentary teeth, mandible.

8.—*Equus sivalensis*, from Gotriala to Besa,—1st molar, right ramus of mandible.

9.—*Bos*, from Gotriala to Besa,—external second phalange, left foot.

10.—*Equus*, Pir Jaffir, Pubbí,—left calcaneum.

11.—*Bos*, Pir Jaffir, Pubbí,—distal two-thirds, left calcaneum.

12.—*Bos*, Kniara, Pubbí,—neural arch and laminæ, thoracic vertebræ.

13.—*Bos*, Kniara, Pubbí,—proximal head of radius.

14.—*Cervus*, Pir Jaffir, Pubbí,—base of left horn.

15.—*Cervus*, Pir Jaffir, Pubbí,—base of right horn.

16.—*Cervus*, Pir Jaffir, Pubbí,—portion of horn.

17.—*Elephas hysudricus*, Pir Jaffir, Pubbí,—portion of molar.

18.—*Elephas insignis* (?) *Ganesa* (?), west of Pir Jaffir,—part of molar; stated to have been found with tusks two feet in circumference; from this probably belong to *Ganesa*.

19.—*Elephas*, Pir Jaffir, Mosque,—part of tusk.

20.—*Elephas*,—part of tusk belonging to No. 18.

21.—*Crocodilus*,—fragment of carapace.

*Note.*—As the fossils of *Bos* are only molar teeth and fragmentary bones, it is impossible to determine the species.—R. L.

## REPORT ON WATER-BEARING STRATA OF THE SURAT DISTRICT, *by* W. T. BLANFORD, F.R.S., F.G.S., *Deputy Superintendent, Geological Survey of India.*

It appears to me, so far as I can form a judgment on the question from the correspondence forwarded to me, that the problem presented may be briefly stated thus: To determine how far the irregularity in the distribution of sweet and salt wells in the Surat district is due to the geological structure of the country, and to ascertain whether that structure renders it probable that sweet water will be found in those parts of the district in which none has hitherto been discovered.

In endeavouring to solve this problem, the first point for consideration is the geological structure of the district, and the second the knowledge which is available of the distribution of sweet and brackish water. On the latter head most of the information obtained is from local sources and not from my own observation, I am consequently not responsible for its accuracy, but any error I may make will doubtless be corrected by the local officers.

The geology of the Surat district is simple.* In the extreme east, about Mándvi and elsewhere, hills of basalt and other volcanic rocks are found. Upon these rest limestones, sandstones, gravels, &c., of tertiary age, the lowest of which abound in nummulites. These

* A sketch of it was given by Mr. A. B. Wynne, of the Geological Survey, in the Records, Geological Survey India, Vol. I, p. 27. I also described it in the Memoirs, Geological Survey, India, Vol. VI, p. 163.

rocks are seen in the Tapti river below Bhodhán and in the Kim river as far west as the neighbourhood of Eláo, but throughout most of the intervening area they are covered up and concealed by alluvial deposits, and they are nowhere exposed, except in one or two small isolated hills, throughout the country south of the river Tapti. By far the greater portion of the country consists of an alluvial plain, the surface being covered with a thick coating of black soil. Along the sea-coast are low hillocks of blown sand.

The alluvial deposits furnish nearly all the water obtained in wells, and these deposits demand therefore rather fuller notice. They consist of clays, sandy clays, and sand, much interspersed in places with concretionary nodules of carbonate of lime. Towards the surface they pass into black soil. They may contain beds of gravel (rolled pebbles) in places, but such appears to be uncommon, so far as my information extends. The different layers of sand and clay are probably very irregular in thickness and extent, but sections are rare, and very few borings have been taken. In those made for the Tapti bridge at Surat, however, as I am informed by the Executive Engineer in charge, a bed of hard clay with calcareous nodules, in which it is proposed to lay the foundations of the piers, was found to be very much thinner on one side of the river than on the other, the difference, which was not precisely determined, amounting to several feet. It is evident that this bed has an irregular and possibly a lenticular section, and the same is probably the case with all the strata in the alluvial deposits, whilst the more sandy layers in which, owing to their greater permeability, water is generally found, may very often thin out and disappear in the distance of a few yards.

I quite concur in Mr. Medlicott's remarks on the different reasons which may be assigned for the occurrence of brackish water in wells. These are, briefly, the presence of salt in the strata when originally formed, salt springs, and infiltration from spots in which salt is being deposited at the surface of the ground. To these may be added percolation from the sea or from estuaries, which, however, is practically identical with the third form. In the case of Surat, I believe that the salt was originally deposited in the alluvial strata.

The plains of Guzerat have every appearance of being estuarine or marine deposits formed from the clay and sand brought down by the Tapti, Narbadda, and other rivers. The deposits forming in the salt marshes and flats submerged at high tides near the mouth of the Tapti, which I had an opportunity of examining during my recent visit, are covered by a deposit differing so little from one form of the bla k soil, that it is impossible to draw a line separating the two, the blackish argillaceous dried mud of the estuarine flats and marshes being similar, both in colour and texture, to the black soil of the fields a few inches above the level of the highest tides, and this soil again differs but slightly, either in colour or texture, from the ordinary 'cotton soil' of Guzerat. Such differences as exist are, I think, due to surface action; to the effect of rain and chemical changes, impregnation with organic matter,* and agricultural processes, and I see no reason for doubting that the whole of the surface formations in Surat may have been deposited from salt and brackish water in tidal estuaries and salt marshes, precisely similar to those which are now being reclaimed and converted into arable land in places on the sea-board of the district. The more sandy beds must have been deposited where some current, due either to tidal or stream action, existed; the fine argillaceous black soil has probably been formed in back-waters and marshes.†

Evidence of recent rise in the land has been found in several places on the western coast of India: instances are known at Bombay, in Katthiawad, and in Sind. There is every reason

* It is probable that great part of Guzerat has been covered by forest, and the soil thus impregnated with decayed organic matter. In this manner the best and richest cotton soil has very probably been formed.

† My brother, Mr. H. F Blanford, several years ago pointed out a similar mode of origin of black cotton soil on the Madras coast, and I found a similar deposit forming under the same circumstances in Orissa.

for believing that Surat has shared in this movement, and that the plains of south-eastern Guzerat have been raised above the sea-level at no very distant geological date.

Such being the geological nature and origin of the alluvial formations which cover the country, it may be inferred that more or less salt must originally have been left in the soil, and that the occurrence of saline impurities at present will depend upon whether they have been removed by the percolation of rain water—whether, in short, they have been washed out—since the deposits were formed. If other conditions remain similar, it is reasonable to anticipate that the salt would be removed more completely from those strata which have been raised to a greater height above the sea and from the more permeable beds, because the first, owing to their elevation, and the second, in consequence of their porosity, have been traversed to a greater extent by water seeking a lower level. It is also probable that elevation has been gradual, and, if this has been the case, it is evident that the surface deposits at a greater height above the sea have been first raised, and have consequently been longer subjected to the action of sweet water. But these more elevated portions of the plains are farther from the sea, and consequently it appears probable that the amount of salt in the alluvial deposits diminishes gradually in passing from the lower ground on the sea board to the higher inland plains, the presence or absence of saline impurities also depending on the more or less porous nature of the beds; or, which is the same thing, the proportion of sand and gravel to clay in their composition. Moreover, as the beds thin out within short distances, and the intercalation of sandy and gravelly layers with the less pervious argillaceous strata is variable, much irregularity in the extent to which the water is impregnated with salt may be anticipated. If the brackishness of the water depended directly on the permeability of the beds, we should expect that the wells yielding the largest supply of water would be the least impregnated with salt, and although this does not appear to be universally the case, some instances in its favor have come to my knowledge in the town of Surat, but the amount of salt in each instance is much complicated by peculiarities in the course taken by the water in reaching the well from the surface, and the beds it passes through during the process of percolation.

So far as I am aware, this theory of the mode in which the alluvial deposits of Guzerat have been formed, and of the distribution of beds containing brackish water, agrees with observed facts. With the important exception to which I shall presently refer, and which I can, I think, explain, of certain perfectly sweet wells close to the sea, the water found near the coast is more or less salt, whilst that obtained in the higher portions of the plains away from the sea is sweeter; but there is much irregularity. I have dwelt at some length on the theory by which I account for the brackishness of the well water, because it is upon the correctness of this theory that the conclusions formed depend; because, by explaining my views fully, I afford an opportunity to the civil officers and engineers of the district to test and confirm or refute them, and because, in one instance at least, I have found theories put forward which appear to me erroneous.

There are two circumstances at least which appear at first sight to be opposed to the views above expressed. One of these is the occurrence, already alluded to, of sweet water in wells close to the coast. I was only able to investigate one instance; this is at some bungalows between the villages of Dumas and Bhimpúr, just south of the mouth of the Tapti river, and about ten miles from Surat. At and around Surat city, on the road between Surat and Dumas, and in the village of Dumas itself, every well which I tried, and so far as I could learn, every well existing, is more or less brackish, some being sufficiently pure for use, whilst others contain water much too salt for either drinking purposes or irrigation. But at the bungalows just mentioned, which are within less than half a mile of the sea, the water in the wells is perfectly sweet. Now, the bungalows stand on hills of blown sand; the village about a mile away is on black soil. The wells at the bungalows are very shallow, I am informed by Mr. Clarke, the Executive Engineer, that the case at Vaux's tomb, especially mentioned in Mr. Hope's letter, is precisely similar to Dumas, whilst at Bhugwa Dandee, where no good water could be found, there are no sand hills. If my explanation be correct, the sinking of deeper wells at the Dumas bungalows or at Vaux's tomb will probably result in brackish water being found in the beds underlying those which now supply the wells.

The other difficulty to which I have referred is the existence of numerous wells in various parts of the country, the water of which is said to have become gradually salter. This is rather opposed to the view above expressed, because it is probable that percolation removes the salt in any given stratum, and consequently wells should become sweeter by use if they undergo any change; that is, provided that the water always finds its way from the surface into the wells by the same route, and traverses the same beds in its course. But the removal of water from a well may occasionally produce an inflow from other strata than those from which the supply was originally derived, and thus salter water may be introduced. The question is a difficult one, and I think some further information on the subject of wells becoming salter is desirable. In the first place, I think the evidence of increasing saltness in wells should be rather carefully examined; of course no analyses of the water have been made, and, so far as I can learn, complaints about water becoming salt have been frequently made in order to obtain remissions of rent, as irrigated land is more highly taxed than land which is not irrigated. I should like to suggest the possibility that, in some cases at least, the change has not been in the water, but in the soil of the fields. As all the well water contains salts in solution, and as the water poured upon the land is evaporated, leaving the salts behind, a gradual concentration of the salt must take place in irrigated lands until it may, unless remedial measures be taken, become so saturated as to be unfit for cultivation, as in the case of the 'reh' lands of Upper India. In this case the blame would infallibly and justly be laid on the water used for irrigation, although no increase has really taken place in the saline impurities contained in the water.

I cannot say how far the wells in and around Surat represent those of the district generally, but if they do, I may add that the impurities of the water are not confined to common salt (sodium chloride). Some rough tests which I have applied with such means as were available showed the presence of lime, alumina, and of an alkaline earth, which I believe to be magnesia, in considerable quantities.

If the views above expressed are correct, it is evidently improbable that better water will be obtained by deep boring, unless the strata at a depth below the surface are much more permeable than the superficial deposits; on the contrary, the deeper beds will have had less chance of being purified from salt by percolation than those near the surface. Where the beds at a greater depth are very porous, they may contain sweet water, but this is by no means certain, and I can see no reason for anticipating that the lower strata will prove very different in character from those exposed at the surface of the ground. Should rock be found, it is impossible to form an opinion without actual trial as to what the character of the associated water may be. The rock may very possibly belong to the lower tertiary strata, and similar beds in Kachh and Sind often yield brackish water.

Before concluding I may briefly advert to the water-supply of the town of Surat, to which my attention has been particularly drawn. I went over the town with Mr. Pandurang

Balkrishna, the Secretary to the Municipality, to whom I am indebted for most of the details mentioned.

Surat is a large town, with a population exceeding one hundred thousand. As in most old cities, the surface has been greatly raised in places by the accumulation of ruins of buildings and rubbish of all kinds. The town stands on the bank of the Tapti, here a tidal river, the water of which is sweet in the rainy season, but brackish at other times, and especially so in the hot weather.

There are in Surat numerous wells, one to nearly every house. The water of only two or three of these is used for drinking purposes; nearly the whole of the inhabitants obtain their drinking water from the river, from cisterns in which rain water is collected, or from wells outside the town. The depth of the wells inside the town varies from about 30 to about 70 feet, and the height at which the water stands in the wells above the datum to which all levels within the municipal limits are referred (100 feet below a fixed mark in the castle) varies in different wells from 50 to nearly 70 feet. As a general rule, the wells inside Surat city contain very brackish water; those outside the city proper, but within the old walls, vary in quality, a few being just drinkable, whilst outside the walls there are some wells of so-called sweet water. This last, however, though far purer than that obtained from the wells inside the city, is decidedly more brackish than good drinking water should be, and on testing it, it was found to contain lime, magnesia, and other impurities in considerable quantity besides common salt. The same remark applies to those wells inside the city which contain drinkable water.

The latter are only two in number: one in the castle and close to the river bank, the other at the house of a Maharaj named Mandir. The former very probably derives its supply from percolation from the river when in flood,* another well not 100 yards away, but farther from the river, yielding brackish water. The well in Maharaj Mandir's house is rather deeper than usual, the bottom of the well being 48 feet, and the surface level of the water 56 above datum, and the supply is so large that an attempt to pump the well dry by a 6-horse power steam-engine scarcely produced any sensible diminution of the water level. At the same time other wells nearly of the same depth contain brackish water.

Two other incidents connected with the Surat wells may be here mentioned. The first is that there is a well in the public park used for watering the gardens: it is 63 feet deep, and contains, when full, 35 feet of water, the surface of the water being about 65 feet above datum. The supply is considerable, but the water can be pumped dry by a 8-horse power engine in 3 hours, and requires 24 hours to refill. After pumping for a short time the water improves, but when the well is left to refill it becomes brackish again. Another well, not 50 yards distant, contains very brackish water. The supply is, I believe, less than in the other well, but I have no certain information.

Another circumstance worthy of note is referred to by Mr Hope in his letter No. 2280 of 1871. A well was sunk at the Surat race-course about half a mile outside the city walls, at a spot in the middle of four existing wells, none of which are more than 150 yards apart. All these wells are comparatively sweet, certainly much better than any well inside the town of Surat, yet Mr. Hope's well proved brackish. In this case I think it is to be regretted that the well was not pumped for some time before being abandoned, since the salt may have been derived from the sides of the well and pumping might have caused an inflow from the stratum which supplies the other wells, but the saltness may have been due to the water finding its way into the well by a different channel to that pursued by the flood supplying the others.

* The statement in a report by Mr. Sowerby on the water-supply, &c., of Surat, dated 7th November 1868, that, the level of the water in the Surat wells is above that of high spring tides in the Tapti, appears to be incorrect.

With reference to the impurity of the wells within the city walls, it is probable that water percolating through the accumulated debris of old mortar, ashes, burnt clay, &c., which have raised the surface of the ground inside the city from 10 to 20 feet, may dissolve a considerable quantity of various salts, and thus increase the saline ingredients of the well water.

So far as I can judge, however, none of the wells in or around Surat furnish water so pure as ought to be obtained for drinking purposes. I am told that no complete analyses of these waters have ever been made, and I should recommend that such be obtained of different waters, including the best and the worst, since the kind of salt present and the relative quantities may afford some clue to their origin.

The details just given concerning the Surat wells are certainly in favor of the conclusions already expressed as to the causes of irregular distribution of fresh water in the soils of Surat. These conclusions I will briefly recapitulate, pointing out their practical application—

1. There appears reason to believe that the greater portion, if not the whole, of the alluvial deposits near the coast of Guzerat were originally impregnated with salt in consequence of their having been formed in salt-water. Where they are now free from saline impurities, this is due to the removal of such impurities by the percolation of fresh water.

2. Such percolation of fresh water has been efficient in proportion to the elevation above the sea, and to the greater or less permeability of the beds; consequently, as a rule, those wells which are at the greatest height above the sea and those which yield the most water are the sweetest.

3. The distribution of permeable and impermeable beds is very irregular, most of the strata being lenticular in section and thinning out within short distances.

4. It ensues from the above, that there is no reasonable prospect of fresh water being obtained from deep borings, unless the strata beneath the bottoms of the existing wells are generally more pervious than those near the surface. This is possible, but there appears no sound reason for anticipating that it will prove to be the case, and it is probable that deep borings will give as irregular results as surface wells.

5. It is also improbable that fresh water will be found in wells sunk in the salt lands now being reclaimed. Should such be found, its occurrence will be, I think, accidental, and due to the existence of unusually pervious strata, and I think that these may very possibly prove local.

6. The presence of fresh water in some places on the coast, as near Dumas and at Vaux's tomb, appears due to the existence of sand-hills resting on impervious clay. The quantity of water will probably bear some proportion to the extent of the sand-hills. Although a considerable supply may be derived from such places for local purposes, I do not think it probable that the quantity is sufficient to supply large irrigation works, nor should I be surprised if in some similar localities the water proved more or less brackish, owing to the presence of salt in the sand, or contamination from the subsoil. Deep wells amongst the sand-hills would probably yield brackish water.

7. None of the wells about Surat town supply really good water, nor is there at present sufficient prospect of improvement to justify the sinking of deep wells, and, as an ample source of excellent water exists in the river Tapti a few miles higher up, and I am informed that it is proposed to introduce the same into the city, it appears scarcely worth while to incur expense in experiments which are very likely to fail.

Finally, I can only suggest that if further information be required, and to test the accuracy of the views here expressed, borings should be made to a depth not exceeding

150 to 200 feet. To attempt to raise water from a greater depth would probably involve greater expense than the value of the water for irrigation would cover. It would be well to make borings along lines, and at a fixed distance apart, in such parts of the district as it is particularly desired to explore. There appears no reason for selecting any locality in particular, for, as I have above shown, the probability appears to me that sweet water will not be found, at all events not as a general rule; at the same time, the matter is of such importance that the trifling cost of a few borings would be fully justified in order to obtain certain information, for, after all, the opinion given above is based upon very imperfect information.

When borings are made the water from every water-bearing stratum traversed should be separately tested, and, at all events, the quantity of salts in solution ascertained by evaporating to dryness, care being taken that some water is always pumped out before collecting specimens for analysis.

I would further recommend that complete quantitative analyses be made of a few of the Surat waters, especially of those in and near the town of Surat,* and I would also suggest that the water of some of the wells which are said to be gradually becoming salter be analysed, or, at all events, the quantity of salts in solution estimated (a very easy matter) from time to time.

As already pointed out, common salt is by no means the only impurity present in considerable quantities in the well water of Surat, and other salts may be equally deleterious both to human health and to vegetation, although their presence is not so easily detected by the taste of the water. It is useless, without more exact information as to the nature and quantity of these salts, to attempt to trace their origin; some have, in all probability, been derived, like the common salt, from the sea; others from the decomposition of the materials forming the alluvial strata.

*11th January* 1875.

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## SKETCH OF THE GEOLOGY OF SCINDIA'S TERRITORIES, *by* H. B. MEDLICOTT, A. M., F. G. S., *Deputy Superintendent, Geological Survey of India.*

Configuration.

Scindia's possessions are so scattered, that any connected physical description of them must include much adjoining ground. The extent and uniformity of the natural features further involve this comprehensiveness, so that the following notice of the geology of the region comprises much of Holkar's territory, all of Bhopal and of the British district of Ságar, all of Kotah, a great part of Búndi, besides some other petty States of Rájputána. All this ground belongs to the Vindhyan plateau, defined on the south-south-east by the Vindhyan range overlooking the Narbadá valley, on the north-east by a scarp overlooking Bandélkand, and on the north-west by cliffed ranges facing Rájputána. Although its limits are so well defined, the character of this area as a single plateau is not well marked. The entire drainage is from the southern edge, the crest of the Vindhyan range; and in their progress to the Jamná the rivers have formed deep and wide valleys, so that a very large area of the so-called plateau consists of plains but little raised above the level of the country to the east and west: still the plateau form is everywhere maintained; the smallest elevations are little table-lands or terraces.

* It should be borne in mind that the greatest care is necessary in collecting samples of water for analyses; such samples should be taken by a responsible officer personally, never on any account by a native servant or subordinate, and both bottles and corks must be perfectly clean Unless these precautions are taken, the analyses when made will be useless.

2. These features are directly connected with the rock-structure. The well known geographical name for the southern crest of elevation has been adopted for the great sedimentary formation which forms the basis of the whole plateau. Except along the edges of their area, the Vindhyan strata are horizontal: and this arrangement, combined with alternations of hard and soft rocks, induces the flat scarped form of elevation. In the south-west part of the plateau in Málwá, where the Vindhyans are so completely covered by eruptive rocks, the same form of elevation is constant, illustrating admirably the step-like arrangement for which the name of trap-rock was originally given to these ancient volcanic products.

Structure.

3. To proceed in regular order from the youngest to the oldest formations, brief notice must be taken of the superficial deposits. There is little or no ALLUVIUM proper in this country, actual land-formation now in progress from river deposits; unless we are to include under this head the almost ceaseless and everywhere present action of wind and rain in shifting and arranging the earth particles at the surface. The soil and subsoil covering is on the whole inseparable from the thick accumulations of clays, sands and gravels occurring over the plains and valleys; although the great depth of these and their forming steep banks high over the extreme flood level of the great rivers, clearly point to conditions of formation separated from the present by marked physical changes, involving a lowering of the water-level in this region. In confirmation of this observation, we find these deposits continuous with those of the great Gangetic plains, in which the remains of extinct varieties of large mammals have been found. The best known locality for these fossils is near Etáwá in the bed of the Jamuná, close to the north-east limit of Scindia's territory. It is very likely that similar remains might be found within the boundary in the Chambal and other large streams.

Superficial deposits.

4. The trap-rock of Málwá is the next in order of age to the valley-deposits, the break in time between them being enormous, embracing nearly the whole of the geological period known as TERTIARY. The formation is known as the Deccan trap, this rock in Málwá being in unbroken connection across the valleys of the Narbadá and the Tapti, with that forming the great plateau of the Deccan. The upper limit of age for the formation is given by the occurrence of NUMMULITIC strata resting upon a denuded surface of the trap along the western base of the highlands near Broach. The lower limit of age is FIXED by the occurrence of CRETACEOUS rocks, supposed to be middle cretaceous, beneath the trap at Bágh in one of Scindia's outlying districts in the Narbadá valley, and also on the plateau near Jábná. Within the formation itself there occur local intertrappean beds, patches of sedimentary rock, earthy and calcareous, frequently containing fresh water fossils. The independent evidence of these has been thought to connect the trap more with the tertiary than with the secondary epoch. The trap belongs to the basaltic family, but presenting many varieties from greenish black, dense, columnar basalt, to porous amygdaloids with agates and zeolites, and to earthy ash-like beds. Within the district under notice no dykes have been observed, showing that it is beyond the immediate region of eruption. The present northern limit of the trap is an irregular line between Nímach and Badráwás. It is purely a boundary of denudation, and it would be impossible to say how much farther to the north the eruptive rock may originally have extended. The laterite band which is so generally associated with the trap may give a clue to this question. There are many kinds of laterite of different ages and modes of origin. The variety here spoken of is a purely earthy ferruginous rock free from sandy detritus, its upper part, to a depth of ten to twenty feet, being intensely hardened by the segregation of the iron. It appears as a capping to the highest plateau of the trap, thus having the apparent relation of an original

The Deccan trap.

top-rock to the formation. If it could be legitimately taken as thus related to the trap, we could assert that this rock had never covered the whole surface in the neighbourhood of Gwalior, for laterite of this type caps the high hill eight miles south-west of the city resting on the Morar rocks, without any intervening trap. A full half of Scindia's territory is on the trap formation. The laterite is finely developed about Guná and Augar.

Cretaceous rocks.

5. Mention has already been made of the small patches of rocks of middle(?) cretaceous age in the Narbadá valley about Bágh and on the plateau near Jábná, both places in or near the Chujerrá district. The most important rock of the group is a limestone holding marine fossils, and underlaid by sandstone, or resting upon the basal crystalline rocks. The infratrappean or Lámeta limestone and sandstone of the districts to the east (Ságar and Jábalpúr) are thought to represent the Bágh beds; but as yet only vertebrate remains, some of great size, but unidentified, have been found in them. This information is given because the ground under description has been only partially examined, so that representations of either group might be looked for anywhere at the base of the trap.

The Vindhyan formation.

6. There is an immense geological gap between the cretaceous beds and the Vindhyans, which are the next oldest rocks in this region. In other parts of India this gap is partly filled up by the great rock series of which the Indian coal measures form a part. Geologically, the Vindhyan plateau is a basin. The lower strata of the formation only appear along the boundary of the field, with a greater or less slope towards the centre in which direction younger beds succeed. The whole series has been divided into the following groups :—

| | | |
|---|---|---|
| Bhanrér ... | Upper Bhanrér ... | Upper Bhanrér sandstone. |
| | Lower Bhanrér ... | Sirbu shales.<br>Lower Bhanrér sandstone.<br>Bhanrér limestone.<br>Ganúrgarh shales. |
| Riwa ... | Upper Riwa ... | Upper Riwa sandstone. |
| | Lower Riwa ... | Jhíri shales.<br>Lower Riwa sandstone.<br>Panná shales. |
| Kaimúr ... | Upper Kaimúr ... | Upper Kaimúr sandstone.<br>Kaimúr conglomerate. |
| | Lower Kaimúr ... | Bijigarh shales.<br>Lower Kaimúr sandstone. |

7. Most of these groups are represented in Scindia's territories north of Badrawás. The Kaimúr conglomerate and its overlying sandstone are admirably exposed about Gwalior. In the fort-hill and the adjoining scarp they rest upon one of the trappean bands of the Morar group. In the hills to the south they rest upon other beds of the same series. Passing north-westward the Panná shales are found in the low ground along the base of the next scarp, which is formed of the Lower Riwa sandstone. Beyond this again there is a third scarp formed of the Upper Riwa sandstone with the Jhíri shales at its base. Still further to the west we find the Ganúrgarh shales and Bhanrér limestone well exposed in the valley of the Chambul, the Lower Bhanrér sandstone forming the Dholpur ridge on the left bank of the river. In the Nimach district the same series is well developed ascending from the west. The Bhanrér limestone is well exposed between Nimach and Chittorgarh. The age of the Vindhyan series is still quite undetermined. All that can be said is that it is greatly more ancient than the base of the coal measure series. Although so undisturbed and unaltered, and apparently so adapted by their varied composition and the conditions of deposition (as indicated by the variety and prevalence of water-marking), for the existence

There is but one other formation to be noticed. Scindiah's territories include a small portion of the crystalline rock area of Bandelkhand. The relation of this rock to the Gwalior and the Vindhyan series has been noticed. The GNEISS is often highly granitoid, but no intrusive granite has been detected. Bands of schists, sometimes hornblendic, occur occasionally, having an east-west strike. The most remarkable feature of this area is the number of great reefs of vein-quartz, forming narrow regular precipitous ridges, with a prevailing north-easterly direction. No trace of gold has ever been noticed about them. The gneiss is also much traversed by trap-dykes; in these a north-westerly direction prevails. They have been found in some cases to traverse the quartz-reefs, and are, therefore, younger than these. But both reefs and dykes are older than any of the sedimentary formations in contact with this gneiss. At the western edge of the trap and Vindhyan plateau, there may be patches of crystalline rocks within the Amjhera and Jawad Nimuch districts of Scindia's territories.

Gneiss.

*April* 1873.

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Specimen (cast) of *Eophrynus Prestvicii*, H. Woodward, *Curculioides id.* Buckland, from the coal measures, Dudley, England. Presented by H. WOODWARD, ESQ.

Series of Brachiopoda from the Jurassic of Germany. Presented by PROF. ZITTEL, Münich.
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Casts of Gastropod from nummulitic limestone near Cherra Punji. Presented by C. K. HUDSON, ESQ.

14*th April*, 1875.

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THE SOCIETY.

*April 14th, 1875.*

# RECORDS

OF THE

# GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1875. [August.


## THE SHAPUR COAL-FIELD, WITH NOTICE OF COAL-EXPLORATIONS IN THE NARBADA REGION, *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*



### I.—NOTICE OF RECENT EXPLORATION.

The question of the coal-supply in the Narbada valley has now been for long before the public, and is still unsettled. Mohpani is still the only locality where workable coal is known to occur; and the extension of the coal here is as yet unproved. Since December 1872, explorations have been carried on in several places under the orders of Government, but so far without result. The region to which these remarks apply is the northern portion of the great Satpura basin of the coal-bearing rocks, within comparatively easy reach of the Great Indian Peninsula Railway. It has long been known that there are numerous outcrops of coal along the south margin of the field; but the distance would greatly add to the cost of exploitation. To that ground, however, we must have recourse if our endeavours to find coal in a more favorable position prove unavailing. With this in view, a survey was made during the past season of the western and more accessible portion of the southern region, known as the Betul or the Shápur coal-field.

Before proceeding to describe this field, with the aid of the annexed outline-map, I would give a sketch of the explorations up to date. It cannot be said that any of the experiments has proved a failure, because no one of them has attained the full limit contemplated for the search. No success, however, can be reported as yet; and in one case some disappointment has to be recorded. Having had the entire responsibility of choosing the positions for the trial borings, I am, of course, anxious, for the satisfaction of Government, that a right understanding should exist of the grounds upon which I decided: it is so easy after the fact to condemn a project as hopeless; and there are always people ready to take the credit of wisdom on such occasions. The data available were never more than could warrant a fair possibility of success, as was duly explained at the first.

The regular mode of proceeding in this investigation would have been to explore the measures at Mohpani—to see how the coal-seams behave on this side of the basin to the deep of their only outcrop. Information might thus have been gained giving some grounds for a definite opinion as to the position and depth of the coal elsewhere along this region. This course was not available, the ground being in the possession of the Narbada Coal Company. The interests of this colliery depend largely upon the conditions in question; but as yet little or no light has been thrown upon them—no coal has up to date (June 1875) been found beyond the limits of the faults against which the original working stopped.

Thus the attempt that had to be made was not that of exploring a known coal-field, but to look for the coal-measures in a great series of formations where it was known they might occur. The explorations proposed were of two kinds: one depending upon the unknown limits of the rock-basin itself; the other upon the unknown lie of the coal-measures within the known area of the basin.

Exploration in the open valley of the Narbada.

So far as appears on a geological map, the northern limit of the rocks with which the coal-measures are associated would approximately correspond with the slightly irregular line indicating the southern edge of the alluvial plains. Along certain portions of that line narrow outcrops are seen of metamorphic rocks; and where these appear, the continuity of the younger rock-basin is, of course, cut off. There are, however, wide gaps where no older rocks appear, where the valley-deposits rest against the coal-bearing formations. It was for a time supposed that the junction of the sandstones with the metamorphic rocks occurred along a great fault, by which the newer rocks were thrown up to the north and removed. Were this so, we should be entitled to draw a fixed fault-boundary to the possible coal-bearing ground across those gaps between the existing outcrops of the metamorphics. From a careful study of the rock-junction where seen, I came to the conclusion that no great line of dislocation could be proved: the actual contact of the two rock-series was almost everywhere found to be the original one. I even got remnants of the younger strata on the north flanks at the same level as on the south of the narrow ridges of metamorphics. It thus becomes apparent that the gaps in the present boundary, where the alluvium laps against the sandstones, may only represent bays in the original edge of the basin of deposition of the coal-bearing formations. A full discussion of this question is given in my last report upon this ground; it can only be by a revision of that discussion that the exploration for coal in these blank areas can be shown to be unwarranted.

The Mohpani colliery, on the Sitariva, lies in the centre of one of the longest of these blank portions of the boundary. Almost the last rock seen in the river is the coal, in full strength, underlying steeply towards the plain. An attempt was made to work the coal here, but it was found to be too much broken and crushed to be worth extracting. It was to the north of this position that I recommended borings to be made in the alluvium, close to the branch railway, where coal, if found, would be very favorably situated. There were of course, other doubtful conditions besides the principal one already indicated: the bay may have been there, and yet the coal deposits have found small place in it: or whatever had found place there may have been to a great extent cleared out by the excavation of the hollow in which the alluvium now lies. The probability, such as it is, of coal existing under any considerable portion of the immense area covered by the alluvium seemed sufficient to warrant some outlay upon the search. Boring was attempted at Gadarwara station and at Sukakheri, at ten and four miles from the boundary. The former trial broke down at a depth of 251 feet. The hole at Sukakheri was carried to a depth of 491 feet, yet without piercing through the valley deposits. Both these trials were started when boring implements were deficient; and although I gave 500 feet as a possible thickness for the alluvium, I certainly expected rock to be struck at a less depth; thus the borings were not begun on a sufficient scale for such a depth where piping had to be used throughout.

There was nothing whatever for a positive opinion that the superficial deposits would be so deep. The Narbada flows on the north side of this broad plain; and within comparatively short distances throughout its course it touches rock, leaving the valley through a narrow rocky gorge 100 miles to west of, and at a level about 200 feet below, the surface at Gadarwara. This gorge is the lowest lip of the rock-basin of the actual valley; for the watershed on all sides is on rock. We have thus at least learned from this Sukakheri boring an interesting geological fact regarding the depth of the pleistocene valley.

A complete prognosis of the case would involve also the consideration of yet another, great valley of excavation in the same area, but regarding which our information is still more obscure. The valley occupied by the pleistocene deposits was to a great extent cut out of the great trappean formation, which had filled up a previous valley to the full level of the highlands on the north and south. Both to east and west of the Sitariva bedded trap is, at several places, the last rock seen passing under the alluvium at the south side of the valley. Locally, too, it is underlaid by thin fresh-water deposits supposed to be of upper cretaceous age. That pre-tertiary valley to some extent corresponded with the existing feature, being principally bounded by the Vindhyans on the north and the Mahadeva hills on the south; but it is improbable that its line of discharge was the same as that of the present Narbada. Regarding its possible relative depth there is no certain clue; but there is nothing to suggest its having been great in the Sitariva region, older rocks being seen at many places to east and west. There were some symptoms that the boring at Sukakheri was approaching a bottom of this kind; the last samples of clay brought up were much charged with granules of iron oxide as if from a lateritic layer which is frequently found coating the trap.

The discovery of the great depth of the surface-deposits at Sukakheri is, no doubt, a check to our hopes of finding the coal-measures within easy reach in this neighbourhood, and may therefore divert the press of exploration to other points; but, of course, the question of the existence or not of the coal-bearing rocks in this position is quite untouched. The argument on this point stands just as at the beginning; and unless before long coal is found under more favorable conditions elsewhere in this Satpura region, I would certainly recommend the prosecution of the search here. The actual position might be shifted to Gagarola, a village a mile and a half south of Sukakheri. I went clear to the north in first choosing a site, to avoid coarse gravels in the covering deposits near the hills, and to get well beyond a known region of disturbance in the coal rocks, should they be found.

Exploration in the hill-region.

The other class of exploration is directed to find the coal-measures within the known rock basin. On the south side of the basin the outcrop of the measures is nearly continuous from east to west. The hope of finding them on the north side is based upon the single outcrop on the Sitariva, and upon the fact that very generally they are closely associated with the Talchirs, and these are found at several places along the north boundary. The reasonable conjecture is, that the coal may be more or less continuous throughout the whole basin, beneath the covering Mahadeva rocks. For a short distance west of the Sitariva the Talchir rocks, and even the coal-measures, are traceable; their manner of disappearance in this direction is not seen; the nearest section is very obscure and greatly affected by trap dikes.

In the first complete section exposed, in the Dudhi and east of it, younger rocks occupy the whole ground up to the boundary with the metamorphics. When next the lower members of the series come to the surface along the boundary, the Talchir group alone is found, overlaid by younger rocks than the coal-measures, the latter being completely cut out, or 'overlapped.'

In explorations of this nature it is commonly the case that some approximation can be made towards computing the depth at which the object should be attained. The simple general rule is — from the proposed point of experiment to follow the descending section directly across the strata to the outcrop of the bed sought for; and then, from the surface distance and the mean dip of the rocks, to calculate the depth from the surface at the required point. Were this rule to hold good in the present case, the coal would be hopelessly out of reach where we are now seeking for it. Throughout this whole central area of the rock basin, the strata have a very constant northerly slope to within a short distance of the north boundary, where, according to the above rule, the depth to the measures would be enormous. The rule, however, works upon the assumption that the beds continue to the deep as they appear at the surface; and it is quite certain that this is not the case with the rocks we have to deal with here. They are for the most part massive, irregular sandstones; and it is demonstrated that not only individual beds, but whole groups of beds, die out to the deep and are overlapped before reaching the north side of the basin. There is no *law* known, or in the nature of the case possible, for such a mode of extinction and succession of stratified deposits. Their distribution depends upon the local physical conditions at the time of their formation, the only evidence for which conditions is to be found in the deposits themselves. Thus, there can be no reason assigned why the coal-measures themselves should not also die out to the north, they being composed of thick sandstones not unlike those above them. The hope that such is not the case rests upon the features along the north boundary, as already noticed.

The facts bearing upon this class of explorations have also been given and discussed in some detail in my last report on this ground; but from the foregoing brief remarks it can be seen that these trials, though under such very different conditions, are of a scarcely less precarious nature than are those in the open valley. It may also here be understood that any offhand opinion on the point can be of no value, unless in so far as it may be based upon reasons such as those indicated.

In selecting sites for these borings, I gave, as for the others, a wide berth to the known difficulties close to the general boundary of the field; such as, firstly, the greater disturbance of the strata, often with trappean intrusion; secondly, the coarsely conglomeritic character of the Mahadevas in this zone, which has proved so obstructive to borings at Mohpani; and thirdly, to give a better chance of getting below the known overlap. To these considerations the surface features added other inducements. On the east and west of the basin, two wide open areas are presented in the valleys of the Dudhi and the Tawa, separated from the plains of the Narbada valley by a narrow belt of low hills. If the Satpura coal-basin ever fulfils our reasonable hopes as regards coal, it is in these areas that the industry would be established, and here that it should be started. Whether or no coal should be found somewhat nearer the surface towards the edge of the basin, it would be a duty to ascertain if it lay within reach of these central areas where mining must be located if it is ever to expand; but to fulfil this purpose the borings here should be carried to the full depth at which there would be any prospect of mining being profitably carried out. Upon this point my knowledge and experience scarcely entitle me to an opinion: I should say conjecturally, that supposing coal to be present, it would pay better in the long run to work it at 150 fathoms in the centre of the field than at 50 fathoms near the margin.

Dudhi Valley.

In commencing operations, preference was given to the Dudhi area, for the reason that the strongest natural outcrops of the coal both to north and south were on the east side of the basin. The borings at Khapa and Manegaon were commenced in the middle of February 1874. Both start in the Denwa horizon of the Mahadeva series. At the close of the season, on the 1st June, they had reached the depths of 260 and 212 feet. After the stoppage of the Sukakheri boring, work was resumed at Khapa and Manegaon on the 15th January 1875. On the 23rd of April work was suspended at the Manegaon boring (at 419 feet), the depth now attained necessitating the constant attention of the European foreman at one boring. At the close of the season (15th May) the hole at Khapa was down to 472 feet. The sections of these borings give as yet no hint as to the prospect of finding coal: the rocks are throughout the same as at the surface, purple and greenish clays, alternating with sandstones, either white or tinted by admixture of the coloured clays. In the Khapa hole the proportion of clays to sandstones is 193 to 279, at Manegaon it is 219 to 200. There is nothing discouraging so far. I have shown elsewhere that the Pachmari sandstone (lower Mahadeva) passes into clay to the deep; and the change to the coal-measures would probably be abrupt.

Tawa Valley.

On the representation by the Railway Department of the importance of a supply of coal as far as to the west as possible, the trials in the Tawa valley were commenced on the 25th December 1874 at Kesla, and on the 1st January 1875 at the Suktawa, under the management of Mr. A. Gardiner, M. E. The latter is entirely in strata of the Damuda formation, on the horizon of the Bijori beds as described in this region, and nine miles south of the Shapur coal-field. The Kesla boring starts in the lower beds of the Mahadevas, somewhere in the Pachmari horizon, so far as can at present be determined, four miles due north of the Suktawa boring; yet, if the structure upon which all these trials depend is favorable, if the Barakar coal-measures rise again towards the north edge of the basin, they may be nearer the surface at Kesla, which is only three miles from boundary of the metamorphics. When closed for the season (30th April) the Kesla hole had reached to 302′ 6″, that at the Suktawa to 241′. Clay greatly preponderates in the Kesla boring, a hard sandy rock variegated brown and red. The Suktawa rock also maintains the same characters as at the surface, alternations of strong sandstone with slightly carbonaceous shales. I do not find in them any grounds for a change of opinion regarding the original project; the depths as yet attained are no greater than might occur at a short distance from the outcrop.

Other trials recommended.

There is, however, already the surety from these borings that mining in this central region will have to be deeper than has yet been attempted in India. For this reason, and to provide against the by no means improbable event of failure to reach the coal-measures at all in this position, it is certainly advisable to commence trials in other ground. Two projects are open to us: to try for the measures close to the north boundary of the basin, in a position analogous to that of the outcrop at Mohpani; and, to commence the exploration of the Shapur coal-field. With this view I have selected four sites for trial borings along the north boundary: one on the road into the Dudhi valley, about seven miles west of Mohpani; one on each of the roads to Pachmari, close to patches of Talchir rocks; and one at Lokartalai. For the southern region I have selected a site near the village of Sonada. One or more of these trials can be carried on at the same time and under the same management as one of the deeper borings in each of the river valleys, say at Khapa and the Suktawa.

## II.—The western extension of the Satpura basin.

The occasional mention of the probable extension of the coal-bearing series beneath the trap to the west of the known Satpura basin, and the fresh demand for coal for the new State Railway starting northwards from Khandwa, led to the request for an examination of the line of ground most likely to throw light on the possibility of finding coal in that direction. At the end of the season I made a tour to the west of Lokartalai along the direction of the north boundary of the basin. There cannot be said to be any immediate practical result, but observations have been made confirming and greatly extending the conjecture upon which the hope was based: direct evidence has been found of the underground continuation of this important series of rocks for some distance beyond the limits hitherto known; and an identification of Mahadeva rocks has been made far to the west on the Narbada near Barwai, which opens the question whether some of the so-called cretaceous sandstones along the valley of this river to near the coast may not belong to the same much older series, and thus be indicators of western coal-fields corresponding with those of the Damuda valley on the east.

No observation has hitherto been made (or at least published) of any appearance to the west of Lokartalai of rocks closely connected with the coal-bearing series. At page 43 of my last report (1872) on the Satpura basin (Mem. Geol. Sur., Vol. X) a brief notice is given of the western part of the northern boundary of the basin. The following remarks are in continuation of those there given. It was said that east of Sali the metamorphics are in force along the boundary. This was hazarded on the strength of a small outcrop at Sali, and of their forming the principal part of the range twelve miles to the east on the high road north of Kesla. I find, however, that intermediately there is an important section in which the Mahadevas are continuous to the plains. It is south of Zumáni in the Narbada valley, and north of Lálpáni in the Táwa valley. Along the base of the hills north-west of Kesla and Táko the Bágra limestone is in force, with a dip of 30° to north-north-west. The overlying sandstone and conglomerate with a low dip in the same direction form the scarp above. From the large and numerous blocks of trap at the foot of the waterfall there is probably an outlying cap of this rock on the hill. The crest of the pass north of Lálpáni is on the southern ridge of the range, on the run of the high dip, 30° to north-north-westerly, in conglomeritic sandstone overlying limestone. There is probably some slip or sudden twist along the north of this ridge, for on the sloping high ground in that direction the strong limestone is again in force, with a low north-north-westerly dip. On the rise to the outer crest of the pass the overlying sandstone and conglomerates come in again. These breccia-conglomerates are splendidly exposed in the steep gorge to east of the road. In a spur near the mouth of this gorge there is a small Mahadeo rock-temple in the conglomeritic sandstone, having a dip of 3° to north-north-west. A little below this the dip rises rapidly to 40°, in hardened sandstone distinctly overlying the conglomerates; there is then a band of crushed rock and a trap dike, but within about eighty yards apparently the same sandstones are again 30° to north-north-west, rapidly falling to 5°. The beds that come in here are peculiar: a whitish sandstone (which has been a good deal quarried), with partings of white shale and a layer of pyritous coaly shale. The character of these beds and their stratigraphical position at the top of a long ascending section of the Bágra group make it highly probable that they belong to the Jabalpur horizon, the nearest known position of which is capping Chátar hill sixty miles to eastward. When last seen in the stream under Jalpa the beds are quite flat, and end abruptly, with some crushing, trap being the next rock seen. This is, perhaps, the most important section we have of the north boundary, as it marks so clearly the upheaval of the Satpura area, or the depression of the Narbada valley, along it. It illustrates and explains some of the sections to the east, especially that on the Anjan (op. cit., p. 37).

The Zumáni section.

About six miles east of Lokartalai there is a fine section of the boundary under the scarp of Budimai ridge. South of Batki the Bágra limestone appears in force in the low ground at the base of the scarp, dipping at 30° to north-north-west, under the trap of the valley. Along the strike to the south-west of those outcrops the limestone disappears, but there is a much fuller section of this fringing zone of rocks. They form quite a flanking range outside the scarp, separated from it by a chain of small longitudinal valleys excavated along the broken uniclinal flexure,

Budimai section.

between the nearly horizontal beds of the scarp, and the same beds tilting down under the plains. Before these beds disappear the dip flattens very much, or even slightly turns up to the north, while near the axis of the flexure it is nearly vertical. I did not here detect any characteristic Jabalpur rock, but unless faulting interferes with the sequence they ought to be represented. The fine Dandiwara sandstone, so much prized on the Great Indian Peninsula Railway, comes from the top beds of these inclined strata. Structurally this section corresponds with that of Zumáni, only the flexure is more marked. It is important to remark that in both cases the sandstones reach well to the front of the run of the nearest metamorphic rock. The strike of the latter into the anticlinal axis rather that they acted as a fulcrum upon which the overlying strata were bent and broken.

The western inliers.

No special disturbance was noticed in the trap on the Moran. In passing to the west-south-west on the strike of the little rib of metamorphic limestone south of Lokartalai, at about a mile distance, there is a low ridge. A clear section of it is seen in the stream, showing it to be formed of trap, with a central band of gray and reddish clay, all having a dip of 60° to south-south-east. In the next stream there is a still better section of this continuous little ridge, just under Sálei village. The clay band here is calcareous, and is locally full of *Physa Prinsepii*, the common fossil of the intertrappean formation. The dip is the same as before. The ridge passes just to south of the village, and immediately north of it there is a strong outcrop of hard conglomeritic sandstone, about 30 yards wide, the dip being 60° to 70° to south-south-east. The trap occurs again immediately north of it. This rib lasts for about a mile, the intertrappean band being traceable much further. In the Ganjál at Uskali, and exactly on the same strike, there is a stronger outcrop of the same sandstone. It has been extensively quarried in the little hill east of the village. The dip here is 45° to south south-east, and in front of it the trap is well seen, although the beds are massive, to have the same dip, gradually lowering to 5° at half a mile up stream. The intertrappean band is absent in this section. Immediately below the sandstone there is a small obscure section of trap. Two miles further, on the same exact strike, at Kupási and Jinwáni, the rib of sandstone appears again, still at 60° to south-south-east, and just under it at Kupási there is a small crop of metamorphic limestone. This is the last appearance of the sandstone, at eleven miles from Lokartalai. The structural feature, however, is well marked for a much greater distance, and exactly on the same strike: south of Padarmati there is an outcrop of intertrappeans still at 50° to south-south-east; in the streams at Káthmákhera and Singanpur, and better still in the Máchak above Magardha, the zone of high dip in the trap is well seen. Beyond this it seems to die out, being scarcely noticeable in the Siáni below Makrai. Magardha is twenty-five miles from Lokartalai.

Interpretation of them.

The feature just described is a very remarkable one. The sandstone of these inliers would seem to belong to the Bágra rocks; it is quite like the rock found near the metamorphics all along the boundary. It is the structural feature that exhibits such a change. Even this might have been anticipated in kind: the steady south-westerly dip of the sandstones on the Moran indicates a depression of the formations in that direction; but it was not there detected that the trap participated in that disturbance. This fact comes out very forcibly from these western sections; and they give one, too, an idea of the magnitude of the event. For a thickness of quite 1,000 feet the trap affects the same steep dip as the sandstones, which must, one would think, carry the latter to at least that depth in the ground to the south. This, of course, would put the chance of coal indefinitely out of reach in this immediate region; the horizontal extent of the feature being quite in proportion to the vertical magnitude. The geological reading of it is very puzzling, especially when it has to be taken from such scattered observations as can be made during a single march across the ground. I can only state the puzzle as it stands. The extraordinary straightness of the feature compels one to consider it as possibly connected with faulting. In this connection especially these western outcrops must be taken as solidary with the rest of the boundary to the east; for the disappearance of the sandstones on the Budimai and Zumáni sections is exactly on the same line. The great contrast, however, in the features of the cross-sections to east and west makes it especially difficult to connect both with one and the same master-dislocation.

Whether faulted.

Apart from the fact of remarkable continuity and straightness, the *primâ facie* suggestion of faulting is the same in the east as in the west of the line. The abrupt termination, with especial crushing, of the flat sandstones at the north end of the Zumáni section, with trap at a lower level close-by in front, is strongly suggestive of faulting with northern downthrow; the only other explanation being the pre-trappean origin of the edge of sandstone. Similar close vertical juxtaposition of formations occurs to the west: trap is found close to the north of the sandstone outcrops, and at a lower level, at Sálei and Uskali, suggesting the same northern downthrow, or else pretrappean exposure. The rock itself of the western outcrop does not suggest any difference of throw east and west. Nor is there any excuse for placing the fault (if there is one) between the sandstone and the metamorphic limestone at Kupási: the sandstone seems to be of the same horizon as that occurring at the same level east of the Moran,—a breccia conglomerate, such as is found in natural contact with the metamorphics all along the boundary; and at the Moran this ridge of supporting rock strikes into the axis of the Budimai flexure, well to the south of the supposed fault-line. Thus from this more direct portion of the evidence, one must, I think, conclude that if there is a fault it is post-trappean, and has a southern upthrow throughout. The collateral evidence, with reference to faulting, presents, on the contrary, a great difference between the eastern and the western areas. The proof of a great post-trappean southern depression by flexure at the edge of the stratigraphical basin to the west of the Moran is now beyond question. This, though perhaps not incompatible with a southern upthrow by faulting along the north boundary of the same area, certainly does not seem to agree with that supposition. The evidence of elevation, by flexure along the same line of disturbance, of the area to the east of the Moran seems equally clear, and this would remove the necessity for upthrow by faulting along the northern boundary, though not incompatible with the co-operation of such a feature. The certainty of the post-trappean age of the western depression might afford presumption that the elevation to the east was of the same age, opposite effects in adjoining areas being rather the rule than otherwise in crust movements; but I shall presently in this paper call attention to the evidence of extensive disturbance and denudation of the Mahadeva and underlying series prior to the outflow of the trap. The fact, as I said, is a very important one; and if it is established at one point on a geological horizon, it must be taken some account of throughout.

## III.—Possible coal-fields on the Lower Narbada.

The Barwai area.

Finding myself at Khandwa, after a vain attempt to discover any further sign of the infra-trappean formations along the Satpuras, I devoted a few days to visiting Barwai, where so many different rock-series are represented within a small area. A combination of favorable circumstances, due to the works of the Holkar State Railway now in active progress, put it in my way to add another to the list of geological attractions of this ground.

The Mahadeva horizon.

When the general description of the western Narbada region was published in 1869 (Memoirs, Geological Survey, Vol. VI, pt. 3), the original conception of the Mahadeva formation—that it was quite unconformable to, and independent of, the coal-bearing rocks of the Damuda series, and superior even to the

Rajmahals—had not been rectified. Mr. Blanford accordingly, in correlating the groups of the lower with those of the upper Narbada valley (which he had not seen), affiliated the Lameta, and with it the Mahadeva beds of the latter, to the cretaceous horizon of the former area. This view has been so far upheld as regards the Lameta group; but in November 1872 (Records, Geological Survey, Vol. V, p. 115), the correction was pointed out as regards the Mahadevas. In making so important a change it might have been thought better to adopt a new name, but if that were done the correction would not have been so apparent—the old name would have held on in its false connection. Besides, the correction was made in the typical area: the Pachmari (Mahadeva) sandstone is now known to hold a middle horizon in a continuously superposed series, of which the Jabalpur (Rajmahal) group is the uppermost, and the Talchirs the lowest member. The original Mahadeva ground contains four well marked groups (Jabalpur, Bágra, Denwa, Pachmari) forming the present Mahadeva series.

True Mahadevas at Barwai.

The correction just quoted led, of course, to the view that there were no Mahadevas in the lower Narbada area; that all the infra-trappean strata there either belonged to, or were closely connected with, the much younger cretaceous group of Bágh. The observation I have now to bring to notice is that there are true Mahadevas at Barwai, unconformable to the cretaceous beds of that place. The proof of this discovery is due to Mr. Moore, one of the engineers at the railway viaduct on the Narbada. Mr. Moore has charge of the great quarries opened at Gatta, on the upland east of Barwai, on the banks of the Choral, and to which a temporary railway is laid from the viaduct. In the bottom of a small valley, about a quarter of a mile north of his bungalow, Mr. Moore discovered a number of fossil oyster shells in a shallow water-course. The ground being quite flat there was no section; so at my request Mr. Moore had a shallow pit sunk, and has sent me the following description :—

| | |
|---|---|
| "1′ 6″ | entirely of oyster shells. |
| 9″ | Thin bed of conglomerate with fossils imbedded. |
| 3′ 3″ | Bed of soft white sandstone; first foot excavated with a pick; the rest harder and distinctly stratified with perfectly level beds. |
| 4′ 6″ | Thick bed (bottom not reached) of water-worn pebbles and small boulders imbedded in stiff yellowish-brown clay or loam." |

From this spot, by sinking shallow pits, Mr. Moore traced the fossil-bed (without getting to the end of it) to within 400 feet of the scarped upland, about 80 feet high, formed of the massive sandstone in which quarries are opened over a very large area. It is a hard white rock with red streaks and mottling. Pebbles (chiefly of Vindhyan quartzite) are scattered through it locally so as to form a conglomerate; but even in the clearest sections in the quarries no regular bedding is visible, the strings of pebbles, however, indicating that the mass is undisturbed. Well marked joint-planes traverse it in various directions. It is a thoroughly consolidated rock, though portions of it are much harder than others through infiltration of silica from the once superincumbent trap. No earthy layer is found in it; and along the Choral it is seen resting directly on the nearly vertical Bijawar limestone and breccias.

One could scarcely desire a more distinct case of a wide geological break than is presented in this section: the petrographical contrast is evident enough from the foregoing description, suggesting in the strongest manner the necessary distinction of the formations. The case for unconformity may not be considered conclusive: a small fault between the oyster bed and the scarp to east of it would account for the actual relative positions; a concealed sharp curve in the bedding would have the same effect; or even it might be an original great bank of sand with the muddy oyster bed alongside of it. Nothing short of an artificial cut across the rocks could finally dispose of all these objections; but certainly the first and most probable explanation is that of original denudation-unconformity. The incompatibility of the even approximate contemporaneity of such rocks as these now are, indefinitely increases this probability.

The oyster bed and its associates are characteristic representatives of the Bagh beds of this region. All the petrographical characters of the Gatta rock point to its being a representative of some member of the Mahadeva series of Central India. I failed, owing to the Huli festival, to get to the larger area of similar rocks about Kátkot. I suspect the great quarries opened there for the works on the ghât are in the same rock as at Gatta.

Inference as to coal.

The observation I have just explained has a very direct bearing upon the object of my trip westward—the possible extension of the coal-fields. It has not been sufficiently noted that the resemblance of the massive sandstones of the lower Narbada valley, especially in the Deva valley close to the alluvial plains of Broach, as repeatedly observed by Mr. Blanford, is a permanent character, and would hold true whatever geological rearrangement the original Mahadeva group might undergo; also, that the connecting of those rocks with the overlying cretaceous beds is given with great doubt by Mr. Blanford, more because he had not detected any break between them, than from any dependence upon their apparent conformability. This missing link of evidence has now been found, and Mr. Blanford's original conjecture confirmed. It is certain that at least some of the rocks in the Western Narbada area provisionally placed with the cretaceous formation are not only lithologically like the Mahadevas, but are stratigraphically related to the cretaceous beds just as the Mahadevas of the eastern area are to the Lametas. There is scarcely much risk in supposing that the sandstones of the Deva valley are the same as the Gatta rock; and if so, the position of the Mahadevas as now understood would give a new significance to the fact, suggesting very directly the possible or even probable occurrence of the coal-measures. It is not for a moment supposed that there are outcrops of the Damudas in the Deva valley; and no probable guess can be made as to the depth at which they are likely to lie; 2,000 is as likely as 500 feet.

The prospect would include the neighbourhood of Burwai. No doubt the rock at Gatta rests immediately on metamorphics; but there are like overlaps of the Mahadevas in their typical area. The Kátkot outlier is also very likely to be shallow. I saw, however, at the viaduct a quantity of cut stone of the same description from a place near Akhund, to the south-east. It is possible this may be the lip of the basin from which Gatta is an overlap, and that coal may be within reach. Of its great value in such a position I need not remark. I had sent my camp by forced marches to Bankeri railway station, and had no means of going about, having already overtaxed the hospitality of the local officers.

A general consideration of the case does not discourage these suggestions. The great Satpura basin almost certainly had its outlet to the west. Its uppermost strata spread out to the east over the gneiss at the watershed of the peninsula. It is not unreasonable to suppose that to the west as to the east of India an expansion of the lower coal-bearing groups took place towards the sea-board, and that the Bengal fields may have underground equivalents in the region of the lower Narbada.

## IV.—The Shapur Coal-field.

Position.

In the event of failure to find coal, and in sufficient quantity, on the north side of the Satpura basin, the alternative will be to take up the most accessible position on the southern outcrop of the measures. In anticipation of this necessity, a survey has been made of that portion of the ground where such trials should be commenced. Throughout the whole length of the basin from east to west, the Barakars are exposed in a more or less continuous outcrop. On the east, where unfortunately the coal is in much greater force, the position is quite out of reach of present demand in an upland valley of the Pench river, which is a tributary of the Wein Gunga, which, as the Prenhíta, is an affluent of the Godavery. The head waters of the Tawa adjoin those of the Pench; but they fall rapidly to a much lower level, flowing at first in deep gorges, which soon open out into broad undulating plains. This broad valley of the Tawa, though containing some large patches of flat alluvial land, is for the most part barren, rocky, and uneven. The high road between Hosungabad and Betul crossing it from north to south is decidedly a rough one.

Map.

The annexed map represents a portion, about twenty miles long, on the southern and western borders of this valley. It is taken from sheets 6, 7, 12, and 13 of the Topographical Survey. The topography is very far from being as accurate as is required for close geological work, but for present purposes it will suffice in the hands of any one in the least fitted to look after coal. The boundaries of the coal-measures are about as close as the transitional character of the formations admits of. The other geological features are accurate so far as given, but a good deal remains to be done in the way of following out trap dikes, quartz reefs, and like details.

General characters of groups.

The first thing to be done is to indicate what rocks constitute the coal-measures, or in a wider meaning, the Barakar group. Coal and carbonaceous shale are seen to be confined to a special line of country; but it soon becomes apparent that the rocks containing them are not constantly separated from the adjoining rocks by any sharply defined features, that in fact, the measures only form a zone, horizon, or group, in a closely connected stratigraphical series. The demarcation of fixed boundaries thus becomes a matter of much difficulty, and must be accepted subject to correction. In the absence, or very rare occurrence, of fossils, the problem has to be worked out conditionally from lithological and stratigraphical data.

The whole rock-series is composed exclusively of sandstone and clays, the former greatly preponderating, except at the base. The character of the bedding throughout is massive, and, as is then generally the case, irregular. It is only in the most general way that either rock can be said to prevail in any particular zone. There are, however, some types of composition and of texture more or less characteristic of different portions of the series, and it is upon these that the discrimination of the several groups in a great measure depends. Throughout a great thickness of strata at the base the sandstones are very fine-grained and of a pale greenish-yellow tint; the clays are hard, splintery, and silicious; both often enclose large erratic blocks and other débris, forming coarse conglomerate, generally with a large preponderance of matrix. These beds form the Talchir group. Above this comes the coal-bearing zone, the Barakars; in which the sandstone is generally white, somewhat coarse and gritty; the clays being shaly and carbonaceous. The sandstone of the next overlying band of the Motur horizon is softer than that of the coal-measures, more earthy and of mixed composition, and having corresponding gray, brown, and greenish tints; the clays are lumpy, sandy, and ochrey. The distribution and the relations of these groups will appear from the description of the local sections.

Conditions of disturbance.

The difficulty of demarcating the several formations is much increased by the disturbances that have affected the whole series, producing intricacies in the boundaries very troublesome to make out where the primary characters of the groups are so undecided. The dips are not often high, but they vary much, and faults are numerous, some having a great throw. There are also many trap dikes and quartz veins or reefs. These are seldom connected with actual dislocations of the strata, but they often disguise the mineral characters of the rock, and thus obstruct the identification of isolated outcrops.

The southern boundary.

The south boundary of the area under notice is the base of the sedimentary series,—the junction of the Talchir group with the gneissic and schistose rocks forming the highland of Betul. For the most part the contact occurs in the low ground along the base of the hills of crystalline rocks. It forms an exceedingly indented outline, being in fact the intersection of two very irregular surfaces—the present ground surface with that of the original floor of deposition of the Talchirs. The actual contact is frequently exposed; nowhere better than in the Phopás (at the south-east corner of the map): the gneissose schists are denuded in the bed of the river, and for several score yards along the left bank the Talchir boulder clay is seen resting flatly on a rough, sharply weathered, ancient surface. At some points this boundary seems to be a faulted one, as in the section of the Amdhana stream at the south base of the Bhaorgarh ridge; the contact here is very steep and crushed, and is moreover on the run of the Machna, north-east to south-west, fault. In the west, at the head of the Bhoura and Súki valleys, the Talchirs rise to a considerable height, forming the upland about Kota, between the Bhaorgarh crystalline ridge on the south and the basalt-capped ridges on the north. The formation is splendidly exposed in the scarps of this small plateau, west of Mura village. The exact position of the south boundary has only been fixed at a few points of our area, the intermediate portions being left uncoloured in the present map.

Northern limit of map.

The northern limit of the area to be described is an arbitrary line in the great sandstone deposit overlying the coal-measures. These beds belong to that middle portion of the Damuda series of the Satpura basin indicated in my former paper as the Motur horizon, in which carbonaceous matter seems to be altogether wanting (but reappearing in the overlying beds of the Bijori horizon). The clays of the Motur group are often slightly ferruginous.

Motur-Barakar boundary

The Motur-Barakar boundary line is, on the whole, well defined. At several distant places, as Dolari and Kosmeri on the Tawa and below Sonada on the Bhoura stream, the contrast is very well marked between the hard white sandstones of the coal-measures and the softer earthy tinted rocks above. On the Tawa below its confluence with the Machna the distinction is not so marked. Some other parts of the boundary are only approximately accurate on account of the covered condition of the ground.

Barakar-Talchir boundary.

The base of the Barakar group is very vaguely definable as a strict geological horizon. The characters of the two deposits are not only blended vertically by interstratification, but it would appear as if this also occurred horizontally—beds of decided Barakar type in one place being represented by as decided Talchir rock elsewhere. Thus it may be that the line given is not truly equivalent in different parts of the field. This feature will be indicated in the descriptions of the different sections.

Four separate areas.

The physical features suggest the division of the area into four portions: on the east a great fault quite detaches the Dolári outcrops from those lower down the Tawa; the great Machna fault cuts off this second area from that traversed by the Súki, and this again is separated from the Sonada outcrops in the valley of the Bhoura by a steep ridge of indurated sandstone along a vein of quartz infiltration.

### THE DOLARI AREA.

Motur beds.

In the Tawa under Dolári village there is the fullest section of characteristically Barakar rocks within this whole district. The steep narrow Lodadeo-Baramdeo ridge has a back-bone of vein quartz, and the sandstone is disguised beyond recognition. In the small stream close under the north base of the ridge, thick, soft sandstone and red and green clay have a northerly dip of 20°. It would seem, therefore, that the main part of the ridge must be formed of these Motur rocks. In the Tawa, to the north, these same rocks have a low south-westerly dip.* Below the Karia stream, the dip is 3° to south on both banks of river for half a mile, and then turns up sharply to a south-easterly dip of 20°, lowering to 10° near the quartz vein which crosses the river obliquely to east-30°-south in the direction of Lodadeo. The same rocks, with a more easterly dip, appear below the quartz reef up to the trap dike which crosses the river to south-35°-west, immediately under the eastern village of Dolári. The dike does not disturb the strata, the same strong bed of mixed earthy sandstone appearing on its west side, where it rests directly on a bed of coal.

Coal-measures: upper beds.

The change of formations is thus lithologically as abrupt at this spot as it could be; but the parallelism of stratification is unbroken. The coal is only seen just under the sandstone, the rest of the outcrop being covered up; but there is room for a large seam. From beneath it there rises a strong bed of white felspathic sandstone. Immediately under this again coal is seen for a small thickness, the rest of the outcrop, full twenty yards wide, being concealed. Below this, for 130 yards, there is white sandstone; then again coal. The covered outcrop of this seam is 40 yards wide, in which some layers of dark shale can be traced under water, but there is room for much coal in the unseen portions. There is then 50 yards of sandstones, and below it 20 yards of covered outcrop with coal at top. This fourth seam is also underlaid by strong white sandstone. These 350 yards of section, with an average easterly dip of 12°, represent about 200 feet of strata, containing what may be four strong seams of coal. I saw nothing to suggest that any of the outcrops are due to repetition by faulting.

Middle beds.

There is a marked change in the character of the underlying measures. The thick rough white sandstones are replaced by sharply defined hard flaggy beds, very fine in texture and of dull greenish-yellow shades, more of the Talchir than the Barakar type of rock; but the alternating shales are copiously carbonaceous, and with some strings and thin beds of bright coal. There is more disturbance in these beds, the dip being sometimes as high as 30°, but in the same easterly direction. The thickness is about 100 to 150 feet.

Lower beds.

Below these thin measures there is still a descending section for over half a mile to where a run of quartz crosses the river from north to south. The only rocks seen in this reach are thick sandstones, in composition and texture mostly of the Barakar type, though some would pass as Talchir, especially the lowest bed adjoining the quartz vein. The intervening earthy beds are completely covered; I conjecture that they are of Talchir type, not carbonaceous. I have, however, coloured the whole as Barakar, not to complicate this small area with boundaries of doubtful nature and position, as undoubted coal-measures occur again close by. The thickness of these lower beds may be 600 to 700 feet.

The Phopás: section and fault.

The quartz vein just mentioned occurs on a broken anticlinal axis; the silica simply filling the many cracks in the fractured sandstone, some central ones being much stronger than the rest. The reverse dip is seen in the indurated rock forming the reef, below which there is a blank of some 300 yards to where sandstone appears in force in the left bank at the confluence with the Phopás. It is a typical Barakar sandstone, and dips south-westerly at 15°. This rock forms the left bank of the Tawa for a quarter of a mile. It becomes much crushed and silicified, and is finally cut out by a run of broken Talchir rock agglomerated by silica. Up the Phopás, there is an ascending section for some 200 yards, the upper beds having somewhat the aspect of Motur sandstone; and they abut at a moderate angle directly against the same crushed mass of Talchirs. There is clearly here a fault of very considerable throw. The ridge of crushed and indurated Talchir rock is about 40 yards wide; and immediately on its south-west side the boulder-clay is quite undisturbed.

The Lodadeo stream.

In the small stream running parallel to the Phopás under the Lodadeo ridge, and at 100 yards from the Tawa, there is a two-feet seam of bright coal, covered by strong sandstone and resting on thick carbonaceous shale. The dip is 23° to west-south-west. For more than a mile in a direct line typical Barakar rocks are exposed at intervals up this stream; the dip is very variable in amount and direction. The last outcrop, at west-6°-north from Lodadeo, is a white sandstone, dipping north-easterly at 15°; Talchir clay occurring close behind it at the same level. The fault here is unaccompanied by any crushing or vein rock.

The Dolári fault.

The above indicate all the outcrops in the Dolári area. The continuation of the measures along the south base of Lodadeo has not been followed out. In the stream north of Dolári, I fully expected to find the repetition of the main section in the Tawa, the ground between being quite flat, with nothing to suggest a great break in the rocks. At the nearest point, however, just to north of the village, typical Motur beds occur, having a low southerly inclination, and continue so to westwards. In proceeding down the westerly reach, there is a run of fracture with quartz veining; and the dip increases, through an ascending section of the same sandstones, to within 300 yards of the Tawa, where it is 30° to south-south-west. The actual rock against which these sandstones abut is not exposed in the banks of the stream; but a little below its confluence with the Tawa, there is a good section of one of the reefs of broken rock cemented by quartz infiltration, so frequent in this region. I believe the rock it includes to be Talchir; but owing to the small scale of the map, I have not complicated it by attempting to represent these small and obscure outcrops. Talchir clay is seen at several points with a low northerly dip on both banks throughout the Baspur reach of the Tawa. There can be no doubt of the presence of a great east-west fault, having a northern downthrow of several hundred feet, bounding the Dolári coal-field on the north. Two miles east of Dolári, at the angle of the stream south-east of Siwanpát, there is an outcrop of broken and silicified rock on the exact run of the Dolári fault. The whole country here north of the Tawa is deeply covered by soil.

Site for a boring.

A boring in the gully between the two villages of Dolári ought to cut all the coal within 250 feet from the surface.

## THE MACHNA AREA.

The Golai reach.

The Dolári fault is well seen in the Tawa at the bend below Baspur. A mass of crushed Talchir rocks indurated by silicious infiltration projects into the river from the west. Close under it on the left bank, massive white Barakar sandstone is seen dipping at a moderate angle from the fault; but within a few yards it turns up to a low southerly inclination which lasts throughout this north-east reach of the river, and as far as a pair of strong trap dikes cutting very obliquely in a nearly east-west direction, across the Tawa, under Golai. The sandstones throughout this length are decided Barakar, and unless repeated by faulting (of which there is no appearance) they represent a thickness of 700 to 800 feet. The outcrop is very little interrupted, but no coal is seen; and such earthy beds as are exposed are only slightly carbonaceous, yet nearly the whole group must be here exposed.

The two great trap dikes south of Golai about correspond with an anticlinal flexure.

The Silapti reach.

At the mouth of the Gonapur stream they are beautifully exposed, cutting sharply through a strong bed of fine pale greenish-yellow sandstone of decided Talchir character. It contains, however, small strings of bright coal; and the gray sandy clay under it, as seen up stream in the Tawa, is slightly carbonaceous. The low northerly dip of the sandstone is not in the least disturbed by the dikes, each about 20 yards wide. The sandstone is continuous down the left bank of the Tawa, gradually rising to the west and then to north, where the gray clay rises with it. Under this another strong bed of fine sandstone crops up in force, ending at a line of broken and crushed ground. As in the Dolári area, I have coloured these doubtful beds with the Barakar group. Beyond the crush, which may also include a small fault, a very typical Talchir rock appears, massive greenish-gray splintery clay with thin bands of hard compact limestone; it is overlaid by thick sandstone like the preceding. All have a low northerly inclination, soon becoming quite flat, and then turning up to the north. These beds are very well seen in the stream between Silapti and the Tawa, and threads of coaly matter are observable in the sandstone. They end along a marked line of fracture crossing the river to west-30°-north; some Barakar-like sandstone occurring immediately to the north of it, and then there is a blank of fifty yards in the section.

It would be impossible to follow closely the lines of this Silapti inlier to east or west, the ground is so flat and covered with clay. In the stream north-east of Golai only Barakar beds are seen, with some crops of very poor coal. The feature north of the Golai dikes is, on the whole, a blunt wedge of lower strata exhibiting two flat synclinal folds with intervening crush, elevated with faulting, and throwing off the coal-measures to the south and north.

To the north of the blank in which the last section ends, thin-bedded measures come

The Temni reach.

in with carbonaceous shales and poor coal, probably representing the middle measures of the Dolári area. The dip is at first southerly, soon turning over in a flat anticlinal, and the northerly dip lasts up to the confluence with the Machna. The outcrops are nearly continuous throughout, strong sandstones of undecided character; the few earthy partings being also uncharacteristic, and but faintly carbonaceous. The whole are, however, Barakar. A thin seam of coal occurs under the great sheet of sandstone on the left bank, at the Temni ford. I saw nothing to suggest a concealed outcrop of strong coal.

So far, in what might be called the main section through this Machna area, there is

The Mardánpur outcrops.

very small appearance of useful coal deposits. It was from outcrops in the Machna itself under Mardánpur that the large quantity of coal was taken which gave such satisfactory results in a trial on the Great Indian Peninsula Railway in 1873. From the confluence of the Machna and Tawa a great sheet of strong Barakar sandstone rises gently to westwards along the bed of the former stream. Under Douri a long deep pool has been cut by the water through this rock into an underlying earthy bed, which is quite concealed, the same mass of sandstone continuing above the pool and extending on the left bank up to where the river bends to the west-south-west. For a hundred yards or so near the bend the sandstones on the right bank have a considerable north-westerly dip; and in the bed of the river is visible the crack along which, by faulting, this abutting stratification takes place. There must also be a south-westerly or some equivalent line of fracture at the back of this upheaved mass of beds. It is at the top of this little section that the coal seams occur, cutting very obliquely across the river bed. At every available point of the outcrop, along a length of some sixty yards, coal was cut on both sides of the river. The holes are now filled in, and little can be seen. There are two seams, the lower one apparently with a strong parting of shale. There did not seem to be in either seam room for more than four to five feet of coal. The dip is 30°. At a short distance up stream the dip changes to north-east, and continues so up the next, north-south, reach. I could not find that the seams are repeated on the reverse outcrop. There is thus here an oblique synclinal flexure, sloping towards the main fault, and the continuity of the coal at this spot is therefore closely limited. The place seems, on the whole, very unpropitious for mining operations.

The Kotmi section.

The next north-westerly sweep takes the river for about half a mile across the main fault into most typical Talchir rocks, the massive fine clay with thin bands of dense, nearly black, limestone. Above this there are again Barakar beds, showing an east-west flat synclinal, south of which a very massive bed of sandstone rises to the next bend of the river. Beneath this rock, along the east-west reach, a band of flaggy sandstones and coaly shales is very well exposed, and the same are traceable for some distance up the gully draining from across the fault to the west. All have a moderate northerly dip, and at the head of the island, at the southerly bend of the river, they are regularly underlaid by the fine Talchir sandstone. These flaggy measures may correspond with those already noticed twice on the Tawa.

The Talchirs on the Machna.

Hitherto we have only seen broken sections between the Barakars and the Talchirs. In the Machna the sequence is quite continuous; and if the conjecture regarding the identity of the flaggy coal-measures here and at Dolári be correct, the contrast between the underlying beds in the two sections is striking: at Dolári the Barakar type of sandstone prevails, while in the Machna, from below the flaggy coaly beds a mile north of Shápur, we meet only rocks of Talchir character. There is another feature in these beds on the Machna different from what is found to the west—the sandstones are in force down to a low horizon in the series, alternating with the boulder clay and even containing large erratic blocks itself. From the Machna the section was followed to the south boundary up the stream flowing near the high road. The moderate northerly dip is remarkably steady throughout, and unless there are repetitions by faulting the thickness would be over 2,000 feet. From the top of the section there are broad intervals between the successive crops of thick fine sandstone. The clays which no doubt occur in these spaces being quite concealed, an important aid was missed in fixing a fair boundary for the groups; the presence of carbonaceous matter was thus also not ascertainable. I did not hit upon the clay with limestone which is peculiar to the Talchirs, though not confined to a particular horizon. The boundary I have given is certainly higher than that taken elsewhere. Locally it is the best marked line in the series, and for coal-searching purposes the most suitable. I had not time to work the question out more minutely.

The Machna Fault.

The Machna fault is quite as well marked as those in the Dolári area, and has nearly as great a throw. The upland to the north-west of it is almost entirely formed of Talchir clay, except the hills north-west and north of Shápur, which are mostly sandstone, perhaps partly Barakar. The Barakars occupy the low ground along the river. The run of the fault is very steady; the bulge appearing in it on the map may be due to incorrect plotting of the river course. At both points where it cuts the Machna there is much confusion of the stratification, with infiltration of silica; but at the only point where I got a view of the actual plane of contact, the feature is very sharply defined. This occurs in a small gully, within fifty yards of the river at the north-westerly elbow above the Murdánpur coal crops. The exact line is not traceable in the covered ground north of Douri, nor can it be fixed on the Tawa. It has probably died out in that direction, as all these features are clearly connected with the special disturbance of the stratification along the margin of the basin. To the south-west the fault is seen at the base of the range of gneissic rocks at the mouth of the Amdhana gorge. Its continuation up the valley has not been followed out.

Site for a boring.

For reasons already indicated, I should not advise any outlay upon an attempt to mine the seams in the detached block of measures south of Murdánpur. If there is any continuity in the measures, the seams should be found in a favorable position away from the fault-ground. A good site for a boring would be on the left bank of the Tawa, a little below the confluence of the Machna. A depth of 400 feet here would probably prove the whole of the measures.

### THE SUKI AREA.

Kosmeri.

The east end of this portion of the field, about Bhumkadhána and Kosmeri, is hopelessly concealed and obscure. From isolated outcrops and the frequent occurrence of vein quartz, it is plain that the stratification is much disturbed. On the left bank of the Tawa at Kosmeri there is typical Barakar sandstone, and on the right bank as typical Motur rock. At a few feet from the base of this latter group there is all along this portion of the boundary an extensive exhibition of trap rock, appearing generally as a sheet-dike along the outcrop of a massive bed of rusty clay. This character is well displayed in the Lohár river, where there is a wide spread of the sandstone covering the trap at a low angle, and broken and altered by it.

The Súki section.

In the Súki itself there is an unbroken section, including apparently the whole Barakar group; and if it is so, the promise of coal is very poor indeed, there being no seam of workable thickness or quality. At the very mouth of the river the strong white Barakar sandstone is in force; typical Motur beds appearing a little to north of it on the left bank of the Tawa; all with a steady northerly dip. At top of an irregular earthy parting in this band of massive sandstone, there are three inches of platy coal. Up stream, in a short west-south-west reach, under the top sandstone there is a flat section of very irregular flaggy sandstone showing already some Talchir characters. Above this there is a long north-south reach with no strong crop, but on right bank the section is almost continuous; a low northerly dip in soft sandstone and sandy micaceous shale. Two of these beds are carbonaceous, with mere strings of coaly matter, the associated sandstone being persistently fine, earthy, greenish. From the upper end of this reach to the causeway at the road-crossing there are continuous crops of strong fine sandstone with a few thick irregular partings of sandy micaceous shale, faintly carbonaceous in strings. The flat reach above the road is along the top of a lower band of softer, finer sandstones, below which the Talchir clays come in with scarcely any associated sandstones. In this section the characters of the two groups are run together in a very puzzling manner: the Talchir-Barakar sandstones are clubbed in force with interspersed carbonaceous matter. The boundary adopted is a very marked one, but manifestly on a lower horizon than that taken on the Machna. If the section on the Machna were to be interpreted by the analogy of that on the Súki, the base of the Barakars should be taken well to the south of Shápur.

Doubtful prospect of coal here.

The question of coal in this locality turns upon whether the shales observed become coal to the deep, and whether some of the top measures may not be suppressed by faulting. I noticed no direct evidence for the latter supposition: there is no doubt much quartz-veining along the boundary at this spot, but I do not think it is connected with faulting; such is rarely and indirectly the case with the many runs of vein-quartz observed throughout the district. The conformable succession of strata here seems unbroken. There is also little encouragement to adopt the other supposition. I would rather connect the want of coal here with the other peculiarities noticed in the original characters of this formation in this position.

West of the Súki.

In the left bank of the Tawa, on the strike of the ridge of indurated rocks separating the Bhoura and Súki streams, there is an excellent section of the bottom Motur beds. There are two strong bands of mottled sandy clays overlaid by thick sandstones. These latter pass up to form the crest of the ridge along the quartz vein. The extension of the Barakars along the base of this steep ridge is quite covered up by débris.

### THE SONÁDA AREA.

The north boundary.

The point at which the Motur-Barakar boundary crosses the ridge of induration is put in inferentially, from the apparent structure, the rocks of the ridge being too much disguised for close identification. The position of the boundary on the Bhoura Nadi is well defined. In the reach to south-east of Bandábir the massive greenish-brown and mottled purple clays of the Motur are in force. A lower band of the same appears near the bend of the river to east-by-south of Sonáda. To the west, along the flanks of Jámgarh, these bands, if present, are concealed by talus. But I rather think they die out to the rise: the sandstone forming the east flanks of the hill are seen to pass down into the low ground to the north; at the high level they are porous and conglomeritic, while low down they become earthy and fine grained.

The coal-measures.

The Barakar beds are fairly exposed for several miles along the Bhoura stream, the course of which is very oblique to the strike of the formations. For this reason and the doubtful accuracy of the map, it is impossible to be certain whether two or more of the outcrops may not belong to the same seam, or to assign an approximate thickness for this group. It is certain, however, that the coal-measure characters are more pronounced than on the Súki. The top rock is as usual a very strong white sandstone. Under Sonáda, near the top of the long west-by-north reach of the river, two poor strings of coal occur in local partings of this rock. Above Sonáda there is a succession of south-westerly reaches, across the measures, and west-north-westerly reaches more or less along the strike. At the northerly elbows between the four first pairs of these reaches coal is seen on the left bank under strong sandstone. The first two are, I think, the same seam, and also the third and fourth, at a lower horizon. From one to two feet of coal is seen in each case; but there is room for more in the concealed part of the outcrop. There are besides several bands of covered ground in these sections that may contain coal. To the west the whole group passes into the base of the Jámgarh range, and is obliquely overlapped by the covering trap which passes across it to rest on the Talchirs west of Teter. The first scarp north of Teter is of coarse Barakar sandstone, locally altered by the overlying basalt.

The Talchirs.

Here again we find an instance of the mutual accommodation that occurs between these two groups: as the Barakar type of sandstone, and with it true coal deposits, increases, the Talchir stamp of sandstone decreases. I have still left a considerable band of these latter within the coal-measures boundary, so as to let it correspond with the continuous line in the Súki area; taking as top of the Talchirs the first appearance of the massive, fine, silicious clays with thin bands of hard compact limestone north of Kupa. Beneath this there are still some strong beds of the fine yellowish sandstone. The very massive Talchir clay is deeply weathered out in the broken ridge south of Teter, showing the quartz veins passing vertically through it. Lower still the boulder deposits are splendidly exposed in the eastern scarp of the Kota plateau.

Site for boring.

The high road (it only deserves the title from the causeways and culverts constructed across the watercourses) passes through the Súki area, which, as has been shown, offers the least promise of coal. For any really effective roadway from the north, Sonáda is much the nearest and most accessible point of the coal-measures. There is no serious obstruction to overcome between it and Dhár on the present road. For this reason it is here that a first attempt should be made to prove the ground for a workable coal, although the apparent prospect of success may be less promising than in the Machna or Dolári area. In choosing an actual site for boring one might at first be inclined to avoid the visibly barren ground at the top of the measures at the bend of the river just above the village. Yet, as none of the outcrops are very tempting, the object should be to test the whole measures a little to the deep of the outcrop. With this in view I should take up a position immediately to the north of Sonáda village. When there is such uncertainty as to the thickness of the measures it is difficult to assign a depth for a boring. If 400 feet at Sonáda did not clear all the measures, the remainder could be tested by another shallow boring half a mile to the south.

## TRAP.

The few trap dikes that occur are not likely to prove very troublesome. The only one seen in the Sonáda area is close to the Talchir boundary. There are none in or near the Súki section. None is seen either in the Machna. A ten-yard dike stops just short of its left bank, at the mouth of the little stream south-south-west of Douri. It is very remarkable for its finely developed prismoidal structure. Two small dikes cut across the Tawa, just below the mouth of the Machna. A boring here might be placed between the two, or below the lower one. Several fine dikes cross the Tawa within this area to south. In the Dolári area a strong dike crosses the river immediately above the outcrop of the coal seams.

The general habit of the trap dikes is to coincide approximately with the lines of flexure, and therefore with the local strike of the strata. The great dike at Kámti and that north of the Tawa at Kosmeri cut across the strike and parallel to the Machna fault. There are some good instances in this field of the tendency of intrusive trap to run out in sheets at the contact of thick clay bands with strong overlying sandstone. The broad run of trap along the north bank of the Tawa in the Kosmeri reach is a good case of this, as already mentioned. There is also a very good example of it in the Talchirs on the Phopás: a band of hard sandstone is seen broken or tossed about upon an underflow of trap. I am disposed to think that the cotemporaneous trap said to occur in the Talchirs elsewhere is only an exhibition of this phenomenon.

I have seen nothing to disturb the opinion I have already expressed that all the trap in these formations is of the age of the Deccan rock. There is excellent evidence within the range of our map of the advanced denudation of these formations at the time of its outflow. The trap forming the summit of Jámgarh is fully 800 feet thick, the top scarp of Motur rocks having an elevation of about 2,000 feet. At a distance of little over two miles, in the gorge west of Teter, the trap is at the lowest level. The fact of there being no infratrappean deposits in such a position only shows that even then this must have been an upland gorge. There is one mode of occurrence of the trap that suggests at first sight an opposite conclusion regarding the periods of denudation. The best case in point I noticed this season, about twelve miles to the east-north-east of Dolári: a very strong dike, traced for several miles along the low ground, cuts straight up the west face of Kilandeo hill and forms a ridge on the summit. It is certain that when this occurred the whole of the present low ground was filled with rock; but it is quite open to supposition that the filling rock was in great part trap. The unquestionable fact, that the main Narbada valley itself, formed on the south by scarps of Mahadeva strata, is re-excavated out of the covering trap-formation—the floor of the valley being still of this rock at many places in front of the Mahadeva scarp—removes any apparent improbability in such a conjecture as that here made regarding the inner vallies of the basin and the pretrappean denudation of the Mahadeva formation. A just estimate of this feature is an important factor in our judgment upon the time-relations of the Mahadeva series, the top member of which is the Jabalpur (Rajmahal) group, in comparison with the Bagh series (cretaceous) in this region; and also upon the distinction of the Deccan and Rajmahal trappean formations.

### QUARTZ-VEINS AND FAULTS.

Quartz-veins: composition.

The frequent occurrence of strong and continuous quartz-veins is perhaps the most peculiar feature of the southern zone of this rock-basin. Along the northern margin, where the contortion of the strata is locally greater than here, I have not observed a single case of quartz-veining; and in other basins of these formations the thing is almost unknown. There is, however, one marked feature of these veins that has long been familiar to us in many parts of India in metamorphic and transition rocks—a peculiar pseudomorphic structure, thin shining plates of pearly white quartz, either in parallel arrangement or confusedly entangled, with empty interstices. I do not recollect noticing this form in vein-stones of other countries; but in India it seems to be nearly universal. The fine lines on these shining plates have suggested that they may be after micaceous iron. Stains of iron are common, but there are no signs of any other metal in these veins. There is often associated brecciated quartz.

Not fault-rock.

The whole rock was for long currently designated amongst us as 'fault-rock.' In highly contorted and altered strata, where this stone was most familiarly known, it is generally difficult to establish the fact of faulting; but in these little disturbed and unaltered deposits the evidence is often complete. From many observations made in this field I can say that this rock seems rather to shun a connection with faults, as if they were related to opposite results of disturbing action—such as if faults occurred along lines of maximum compression and these veins along lines of tension. The vein forming the core of the ridge between the Súki and Bhoura streams is at least eight miles long, varying from one foot wide in the Talchir clays to six feet in the sandstones. In the masive unstratified clays vertical dislocation might not be detected, but there is little or no sign of crushing or rubbing alongside the vein, clear sections of which are abundantly exposed in the broken ridge south of Teter. In the sandstone it is quite surprising how this fissuring of the rock and introduction of foreign matter does not even locally derange the moderate dip of the bed: an indurated shell of sandstone of variable width commonly adheres to the south face of the vein, to the rise of the dip; and in this, as well as in the strips of rock enclosed by the ramifications of the veinstone, the low northerly dip is uniformly undisturbed. The best defined and most continuous of the quartz-runs correspond with this description. The few cases where the quartz appears locally near the Dolári and Machna faults might be quoted on the other side; but besides that these spots are quite local as compared with the length of those faults, it can generally be seen, as in the Tawa and the Phopás, that the quartz is located in broken flexures adjoining the fault, where no vertical displacement has occurred, and does not represent what is properly designated by the term fault-rock; it is simply veinstone. One of the veins which have given rise to the group of sandstone ridges north-west of Shápur is seen on the path descending the Amdhána gorge to the south, to run continuously into the gneiss as a comb-vein one foot wide.

Peculiar local structure.

The structure of some of these runs of vein quartz is peculiar: the small veins of which the reef is made up are not always coincident with the general direction. In the hill north-west of Bhoura the component veins are nearly normal to the direction of the aggregate. In the Tawa above Temni the run of the quartz rib is east-west, while the veins composing it lie north-east,.south-west. It is perhaps conceivable that 'colliding' earthquake waves might shatter the rock in this manner.

Peculiar induration.

The induration and metamorphism of the sandstone that occurs in connection with this infusion of quartz is sometimes remarkable, as it takes the form of felspathisation, the development of innate crystalline felspar. I noticed this at the contact of the Lodadeo reef in the Tawa. It is important to find it in this connection, because the most marked case I found of this form of induration is not visibly connected with any veining. It is in the small hills on the Bhoura stream south-west of Bandábir. They are formed of sandstone having quite a granite-like hardness; the porosity of the sandstone is not destroyed, nor is the earthy matrix quite obliterated; but bright glassy facets of a felspar are disseminated, manifestly innate; and it must hold the whole in an invisible bond to account for the peculiar hardness of the rock.

Faults: dimensions.

The well-marked faults within the stratified series form another peculiar feature of this region. We are familiar enough with the word 'fault' in the northern region, about Mohpani; but they would be correctly termed slips in comparison with the principal faults in the Shápur field, where top Barakars or even high Motur strata are brought into contact with middle or lower Talchirs; in which cases the throw must be from 500 to 1,000 feet.

Local relations.

Notwithstanding the dimensious of these faults, I cannot look upon them as anything but local features, not merely in the literal and obvious sense, but as connected with and determined by pre-existing local conditions. The Machna, north-east-south-west, fault runs with the crystalline range of Bhaorgarh; but I cannot regard them as concomitant effects of elevating action. I rather connect the fault with a pre-existing feature of the basin of deposition, of which there seems to be coincident evidence in the marked change in the character of the Talchir strata along that line.

Different throw in east and west.

The only noteworthy instance in India of Barakar deposits occurring at a high elevation is on the continuation of these outcrops to the east, in the Pench valley. The case has been appealed to as a sufficient refutation of the general remark that the areas of Barakar deposition correspond in a recognisable manner with the existing depressions of the peninsula. The objection, however, will not hold if it is shown that the apparent exception is due to local elevation; and there seems every probability that such was the case. But for the great faults which set on to the eastward fro.n Shápur, the coal-measures here would correspond in position with those in the Pench. The fault which brings up the coal on the Pench river west of Chendia has, on the contrary, its upthrow to the north: here, too, the quartz veins keep clear of the faults.

The structural features of this region offer a most tempting subject for study. I believe it will appear that the limitation of the sedimentary basin here is not in any important degree due to elevation from the south; but rather that this present local stratigraphy is connected immediately with pre-existing surface features.

## SUMMARY.

Although the foregoing details are reduced to the minimum required for any one who would carry on the investigations described, or even as evidence for any one who would study the questions discussed, each of which is marginally noted, it may be well briefly to point out what conclusions or opinions have been arrived at.

As to coal: the only tangible and immediate prospect is, of course, where we are certain of the coal-measures; I think there is a good prospect of coal in the Shápur field; if not in the Sonáda area, then further east, on the Tawa.

Regarding those places where we are searching for the measures themselves, I can only say that there is a reasonable hope of finding them. In the central area, where the deep borings are being made, the chief risk is that the measures are out of reach. In the trials along the border of the basin the extra hope is that the measures, if there, have partaken in the extension and rise of the Talchir beds towards the northern outcrop; the extra risk, that the boring may be outside the overlap.

The prospect held out of coal on the lower Narbada is in some ways more precarious, the ground being so very far from any known occurrence of the coal-measures; yet the countervailing suggestion of a probable original expansion of the measures towards the sea-board is not without weight; and the presence of a rock that is known to overlie most of the important coal-basins in India is no small encouragement. Considering the importance of a local supply in Western India, the chance ought not to be left untried.

## NOTE ON COALS RECENTLY FOUND NEAR MOFLONG, KHASI HILLS, *by* F. R. MALLET, ESQ., *Geological Survey of India.*

On the 19th April 1875, I visited the coal recently discovered near Umsaomát and at Dédúm Hill.

Two spots were pointed out to me near Umsaomát, one about half a mile, and the other a mile south-east of the village. The coal at both these places is worthless, being shaly, and the seams only a foot thick.

The following assays have been made of the Dédúm coal, and for comparison of that at Máobeláka, the latter seam is that which for some time past has been worked for the supply of Shillong with fuel:—

| | Dédúm Hill. | Maobeláka. |
|---|---|---|
| Hygroscopic water ... ... ... ... | 6·0 | 3·4 |
| Volatile matter, exclusive of water ... ... | 24·6 | 39·6 |
| Fixed carbon ... ... ... ... | 37·8 | 55·2 |
| Ash ... ... ... ... | 31·6 | 1·8 |
| | 100·0 | 100·0 |

The Máobeláka coal was taken from the fresh working face of the quarry, while that from Dédúm was from the surface of the weathered outcrop. The latter coal would probably be found considerably better a few feet in. The seam is three feet thick (the Máobeláka coal being 3′ 6″ to 4′ 0″), but the outcrop is at the foot of a perpendicular sandstone cliff 15 feet high, from the top of which the hill slopes back steeply for 30 or 40 feet more. The hill near the top of which the seam is situated appears to be equally steep all along the southern side, so that the coal could not be quarried. If sufficiently good in the interior, however, and no better seams should be found in the neighbourhood, it might be worth mining on a small scale, as when the projected new road is completed, the facilities for carriage from Dédum to Shillong will be considerably greater than those from Máobeláka. The roof is good and the seam horizontal, and a few miners could raise sufficient coal to supply Shillong. The chief difficulty in the way of opening such a mine under native supervision would be the risk of explosions if it were not properly ventilated.

## DONATION TO MUSEUM.

DURING APRIL, MAY AND JUNE.

Laterite from Pigeon Island. Limestone from Bittrapar one of the Laccadives, and Rock specimens from the Vingorla rocks. Presented by A. O. HUME, ESQ., *Secretary to Government of India.*

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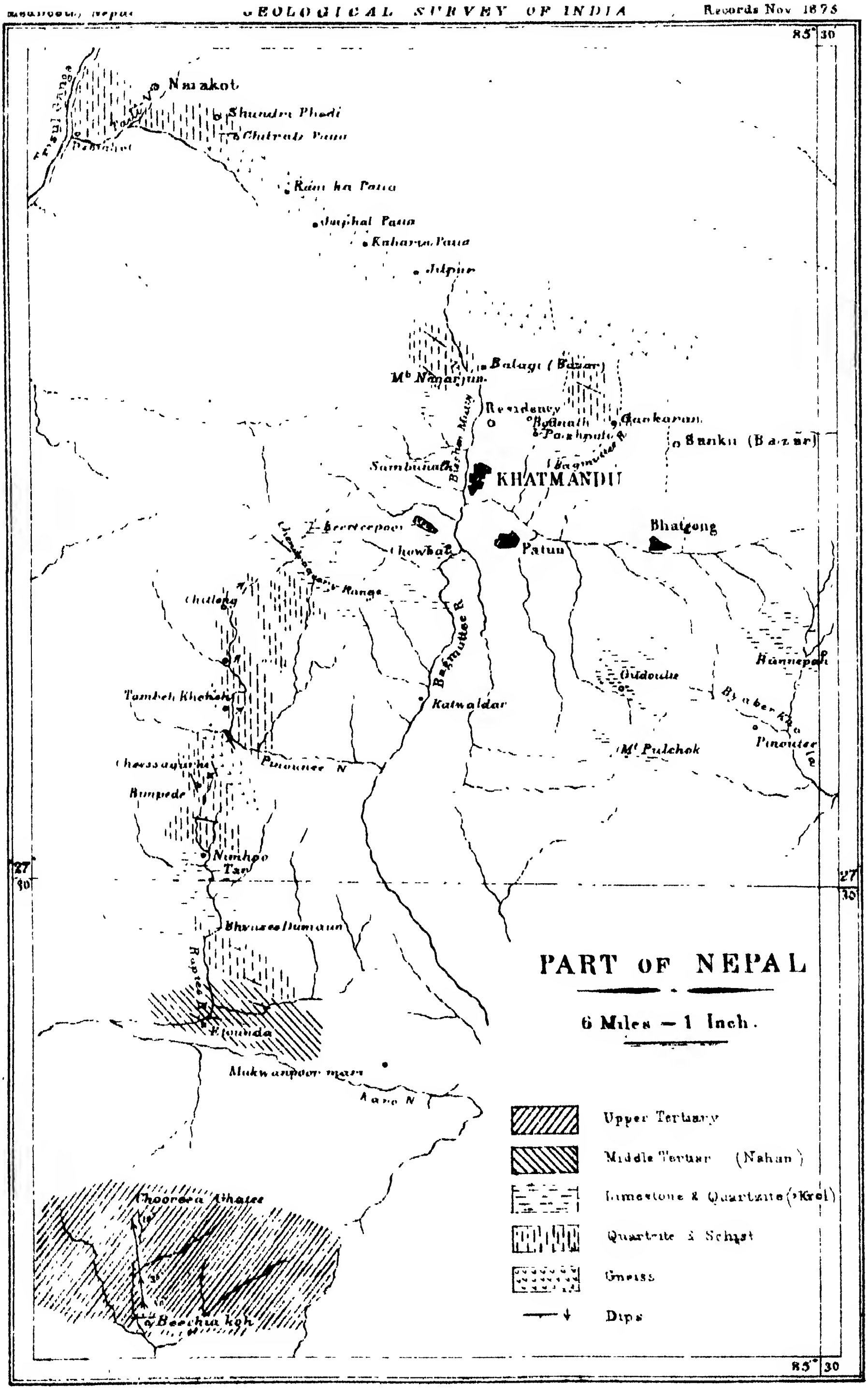

Nayakot
Shundra Phedi
Chitrala Pana
Ram ka Pana
Jiuphal Pana
Kahara Pana
Jalpur
Balagi (Bazar)
Mt Nagarjun
Residency
Budnath
Pashpati
Gankaran
Sanku (Bazar)
Sambunath
KHATMANDU
Bagmatti
Bhatgong
Patun
Chowbar
Range
Chitlang
Tambeh Khehsh
Bagmuttee R
Katwaldar
Gudoulie
Hannepal
Mt Pulchok
Pinouter
Punounee N
Bimpede
Ninhoo Tar
Bhyasee Dumaun
Raptee R
Etounda
Makwanpoor mari
Karo N
Chooreea Ghatee
Beechia koh
PART OF NEPAL
6 Miles = 1 Inch.
Upper Tertiary
Middle Tertiary (Nahan)
Limestone & Quartzite (Krol)
Quartzite & Schist
Gneiss
Dips
85° 30
27 30

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1875. [November.

## NOTE ON THE GEOLOGY OF NEPAL,* *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

Through the kindness of Mr. Girdlestone, the Resident of Nepal, I had an opportunity in May last of visiting that very secluded country. It will surprise many to hear that although the marches of Nepal run for more than 500 miles along some of the most fertile and populous districts of British India, that country is still rigorously tabooed to all outsiders, Englishmen included. With the exception of the track to Katmandu, no part of that extensive area has been traversed by civilized man. Even the route to the capital is only open to political envoys, and by special favor to invited guests; and any digression from the actual road-way is suspiciously watched. The permitted range of exploration from Katmandu is correspondingly restricted: one may go as far as the Trisal-ganga, on the north-west, about sixteen miles (direct), and to about an equal distance on the south-east, in both cases a short way beyond the precincts of the actual valley. The following observations are therefore most scanty, there being no opportunity to follow up and examine features of special importance in the general section. They may, however, have some interest as a term of comparison between the known ground on the east and on the west, about midway between which this section occurs.

It is necessary briefly to state what the features are with which this comparison is to be made. From the Sutlej to the western frontier of Nepal there is continuously traceable along the margin of the mountains a zone of variable width formed of slates and thin silicious beds surmounted by sandstone and strong limestone. The latter have been described as the Krol group; the lower horizons being distinguished as infra-Krol, Blini (a thin limestone) and infra-Blini. They usually form a broad, crushed synclinal ridge at the edge of the mountain-area, as at Mussooree and Naini Tal. In the Simla region they extend far beyond this ridge into the interior of the mountains, where they become obscured by metamorphism, their relation to the gneiss rocks not being as yet satisfactorily determined. In Kumaon, at least north of Naini Tal, there is an abrupt change, along a line of trappean intrusion, between the range of semi-metamorphic strata and the gneiss rocks to the north. It has been conjectured that the Krol limestone is triassic, and the underlying groups palæo-

* Within the territories the name Nepal is only applied to the valley of Katmandu.

Although this Chessa-garhi range has a nearly east-west direction, parallel to the strike of the rocks to the south of it, it is formed, at least at this point, of rocks having a widely different direction. Even at Bimphedi, at the south base of the ridge, the strata strike to north 35° west. They are again thin quartzites, greatly folded and shattered, but maintaining a dominant high underlie to north-east-by-east. A little below the crest of the ridge on the northern descent, the quartzose schists are associated with strong bands of prophyritic gneiss, which is the dominant rock towards the base. The strike would take it into the ridge well within the basin of the Rapti. At the north base of the range the Pinouni river flows from the north against this mass of gneiss, and turns away to the east. Just above the bend of the river there is a cliff-section showing the crushed condition of the gneissic strata, contrasting well with the steady high underlie of the sharply bedded quartzites through which the river cuts its way obliquely. The general strike in both rocks is the same; and the whole feature suggests that the gneiss has been formed, and perhaps faulted up, along a broken anticlinal axis of flexure. It is near this line of disturbance that the copper mines of this locality occur. I was, of course, unable to visit and inspect them; but by a curious coincidence I passed at this very place a number of coolies laden with foreign copper for Katmandu, which suggests that the native resources in this metal cannot be very great. Here, and at several other places where I saw abundant refuse of old copper smeltings, the work seems to be now abandoned.

From the Sango bridge at Tamba Khoneh, along the Pinouni nearly due north to Marku, and then up the Chitlong valley to the north-east, there is an ascending section (obliquely) through the sharply bedded quartzites underlying steeply to east-35°-north. Wherever their composition is more earthy, foliation is well marked; but I did not see any gneissic band. Towards the head of the Chitlong valley the strike of the rocks becomes more easterly, up to the Chendragiri ridge, where it is east-15°-south; and the rocks are freely calcareous.

The Chendragiri ridge overlooks the Nepal valley, which is enclosed, except on the north, by rocks of the same description as those found here. There is, however, nothing like a circular arrangement of the ridges or of the rocks; the strike of both is most constant, between 15° and 25° to south-of-east; and the form of the valley is consequently most irregular—a number of longitudinal valleys, united in a central area by the suppression of the ridges, which are in some cases mere spurs running a short distance into the open; others, again, as that of Kirthipur, are nearly continuous across the valley: sometimes, as at Pashpati, the rock appears isolated in the alluvial deposits. The south-west corner of the valley divides the Chendragiri from the Phulchok range, on the same strike. Here at Kátwaldár, the Baghmati leaves the valley through rocky gorge across vertical quartzites. It is a moderately sized torrent, the watershed being confined to the ridges immediately surrounding the valley, which is only about sixteen miles long from west-north-west to east-south-east, and about twelve miles transversely, from Katawidár to the base of the Sheopuri range on the north. The alluvial area may be about 125 square miles. The elevation of Kátmandu is given as 4,500 feet. Phulchok on the south-east is the highest summit of the surrounding hills, rising to 9,720 feet.

Excluding the Sheopuri range on the north, all the ridges skirting or abutting into the Nepal valley are formed of steeply folded repetitions of one set of rocks, in which, as already noticed, a calcareous ingredient is very general. It often appears as limestone, in some force and of various degrees of purity. The summit of Phulchok is of thick white crystalline limestones. Strong beds are also found on Chendragiri and Nagarjan, both of which are synclinal ridges. The pure rock would thus seem to occur chiefly near the top of the series, but some single beds are found low down. The schistose limestone of which the monoliths of Katmandu and Patun are made is quarried low down on the Kirthipur ridge at Choubal, where it is well seen at the gorge of the Baghmati. There are some thin bands of limestone also in the gorge at Pashpati. The prevailing rock is a peculiar massive, very fine schistose quartzite with a trifling percentage of carbonate of lime, yet to this minimum ingredient is, I believe, largely due the physical condition of this mountain zone—its deep erosion, as chiefly exhibited in the basin of the Nepal valley. This rock is very prone to decompose, by the abstraction of the small calcareous element in it, and is therefore seldom found in clear out-crops. It is well exposed in the little stream at the north-west side of Sambunath. For the most part it forms at the surface an ochrey sandy clay. When only partially decomposed it forms what might be called a sandstone (freestone). In this state it is quarried at the base of Nagarjan for building.

From the frequent reappearance of similar rocks across a broad zone of more or less vertical strata, one might of course presume that there is repetition by folding; but this condition is independently established: both Chendragiri and Nagarjan ridges, and those flanking Phulchok, are on synclinals. There would thus seem to be from the Pinouni into Nepal a repetition of the structural feature observed in the outer zone along the Rapti valley—an ascending section, only affected by minor foldings, through thinly bedded quartzose schists into a broad many-folded synclinal, in which an upper group of calcareous strata is frequently repeated at the surface. There is also sufficient likeness in the two series to suggest that they belong to the same formations, the most marked difference being the concentration of the calcareous element at the top of the southern section and its dispersion in the upper part of the northern one.

I would further venture to suggest that this series may be the continuation of the Krol and underlying formations of the Simla region. The flaggy quartzites of the lower horizons in the Nepal sections would very fairly represent the thin silicious beds that form so large a part of the Simla slates, or infra-Blini zone. Cases have, moreover, been recorded of the Krol limestone being represented elsewhere by more or less calcareous sandstone: a relation quite analogous to that now suggested between the strong quartzite and limestone of Bhainsi Daman and the calcareous quartzites of Nepal. Katmandu is in about the same zone of the mountains as Simla and Almora, being only thirty miles in a direct line from the plains. There are two points of contrast between the section here and in the Simla region, supposing the rocks representative: the contortion and the metamorphism of the strata in the latter position are local and partial, whereas in Nepal they are general and more or less complete. The limestone on the crest of the Chendragiri pass between Chitlong and Nepal is somewhat less altered than usual; in it I noticed some small facets of spar having a central puncture, and which I tor' to be crinoidal; but Dr. Waagen could not say positively that they were so.

On the north-north-east side of the valley the alluvial deposits rest against gneiss at the base of the Sheopuri range. The white patches so conspicuous along this edge of the valley are slip-faces in this rock where it is deeply decomposed. It is a coarse felspathic gneiss with much silvery mica and schorl. Its débris is a prominent ingredient of the valley deposits at Katmandu. On the spur north of Bodhnath and that connecting Sheopuri with Nagarjan, one finds very fine mica schists, first alternating with, and then succeeding to, the gneiss. The compression of the whole is so excessive and the underlie so variable, that it would be impossible to conjecture, without very detailed study, what the normal order of the strata may be. On nearing Nagarjan the underlie sets towards it; but the flaggy quartzites of Chitlong, which certainly underlie the calcareous zone, are not specifically recognisable in the

The section in Sikhim, to the east of the Nepal territories, is petrographically very different from that in the Simla region. The schists and gneiss come close to the edge of the mountains, in some places quite up to it. But in many parts there is a narrow band of partially altered strata, which have been fully identified as belonging to the Damuda formation, the coal-measures of India, thought to be of upper palæozoic age. But the curious point is that these beds are the lowest and oldest member of the rock-series, conformably underlying the schists, and these again passing regularly beneath the gneiss, which forms the greater part of the mountains in the Darjiling district. In Sikhim the usual outer ranges of the sub-Himalayan hills, enclosing long valleys at the base of the mountains, are not represented. The inner zone of sandstone at the very base of the mountains is, however, in force.

In the Nepal section we find a very complete exhibition of the sub-Himalayan hills, as known to the north-west. The Churia Ghati range, in size, structure and appearance is a *fac simile* of the original Sivaliks. Inside it the *dún* or *mari* of Etoundah is an excellent example of these characteristic sub-Himalayan valleys. And to the north of this, along the base of the mountains, there is a flanking range of sandstone, harder, and apparently older, than that of the outer hills, just as occurs in the western region. There is still so much uncertainty about the grouping and distribution of these sub-Himalayan rocks, that I cannot speak confidently as to those in the section under notice. It is quite recognised that there are two strong and stratigraphically well separated groups—the Sivalik and the Nahan—in the trans-Jumna region; but considerable doubt has been thrown upon the view I at first adopted, that the cis-Jumna Sivalik hills belong to the upper group of rocks. Lithologically, the resemblance is more with the Nahun than with the Sivalik group. Thus it would appear that structural position, even in the case of what is physically a single range, is no criterion of the geological horizon of the rocks; and we are unable on these grounds to assume that the Churia Ghati strata are true Sivaliks. Lithologically too, they have small resemblance to the typical Sivaliks of the trans-Jumna range. In mere composition they are much more like rocks of the cis-Jumna hills, consisting as they do in the lower half, of massive gray sandstone, and above of great beds of conglomeritic gravel. There are, however, some points of difference: in the west the change from the sandstones to the conglomerates is gradual and alternating; here it is rapid and complete, from an almost unbroken mass of fine grey sand to an equally uniform mass of pale yellowish-brown conglomerate. This character can have no significance; but I was much struck with the very fresh aspect of these Churia Ghati deposits as compared with those of the range south of the Dehra-Dún. The sand, in solidity as well as in appearance, is scarcely different from that forming the *chars* (temporary islands) in the great river beds. I should, perhaps, mention that it is several years since I have seen the Sivalik sections, and have since then been occupied with much more ancient formations. On one point, however, I will speak firmly: I must at present refuse to believe that the Churia Ghati strata can be of the same horizon as the sandstone forming the hills north of Etoundah; and so, these being presumably Nahans, the former may for the present be set down as Sivalik.

At the outer base of the range, at Bichiakoh, there are some rusty earthy beds; and all are greatly crushed, locally quite vertical. The dip soon settles down to 30°, to north-north-west, maintaining it steadily to the top of the pass. This is the type structure of these detached sub-Himalayan ranges, of whatever group composed: the flat half of a normal anticlinal flexure. The range is about four miles wide, which would give an aggregate thickness of about 10,000 feet of rock.* The pass, as is universal in these ranges,

* It is still necessary to note that this does not imply vertical sequence.

follows the broad bed of a torrent, to near the very summit, where it turns up a steep gully, partly artificial. Here I noticed a strong bed of ochreous clay. A similar rock is very common in a like position in the passes south of the Dehra-Dún. Boulders of from 12 to 20 inches cube are common in the bed of the torrent, though it is rare to see stones of this size in the conglomerate forming the cliffs on each side, from which, it would be assumed, all must be derived. Near the foot of the steep rise I observed a huge block of quartzite, measuring 10' × 7' × 6'. Reference to it will be made further on.

In the Rapti, immediately under Etoundah, there are outcrops of the rusty sandy clays and greenish-gray sandstone at the base of the section north of the dún. They dip at 60° to north-by-east. Wherever observed along the road, this dip (with slight variation in amount) was found constant, and there is but little change in the character of the rock. It is clearly an ascending section: clays occur, but very subordinately; the sandstone becomes somewhat softer in the higher beds, and there are here several layers of thin conglomerate. In no single feature is there any precise resemblance to the series in the outer range. The strata closely correspond with the Nahan group of the north-west, and with that described by Mr. Mallet at the base of the Sikhim Himalaya. At Etoundah the formation is about a mile wide, which would give an accumulated thickness of about 10,000 feet, there being nothing to suggest repetition by faulting or flexure. A blank covered space of fully 100 yards, between the last outcrop of the sandstone seen on the road section and the first outcrop of the slates, conceals the contact. It is probably, as usual, very steep, if not overhanging. Mr. Mallet has adopted for the Sikhim ground the view I put forward regarding this main feature of the mountain-structure in the north-west, that it is not primarily a faulted rock-junction. There is no sign at the base of the section, nor as a remnant along the junction, of any older tertiary rocks that might represent the eocene group of Subathu. The inner limit of these sandstone hills is well marked by narrow longitudinal valleys of denudation.

The first rocks seen north of the tertiary sandstone are some earthy schists, with a crushed dip of 50° to north-by-east, quite parallel in strike to the sandstone. A thin band of blue limestone occurs in these beds, and further on a strong band of black schistose slate, in which are some irregular vein-like nests of impure carbonaceous matter. All these beds within a few hundred feet of the boundary, though decidedly subfoliated, are less altered than any rocks to the north of them, and also less highly inclined. They are overlaid by more silicious rocks, flaggy schistose quartzite, nearly vertical, or folded in zigzag contortions. There is again a small appearance of more earthy schist, or possibly a reappearance of the former band, for the beds are greatly contorted, although the northerly underlie seems constant. A trappoid rock occurs here; but its intrusive character is not well marked. It is the only rock of this kind that I observed in Nepal. The thin quartzites come in again and pass up into stronger beds of the same rock, which are overlaid by massive white crystalline limestone, all dipping at 70° to 80° to north-by-east. This limestone must be several hundred feet thick. The sample I brought with me is not dolomitic. At Bhainsi Daman, where the river takes a bend, and above it for some miles, the rocks are much broken and confused. Great masses of the white limestone form irregular cliffs on both sides, the underlying rocks being concealed by vegetation and valley-deposits.

It would seem as if the ascending section from the boundary to Bhainsi Daman here passed into a broad, broken and contorted synclinal basin. The east-by-south general strike is maintained throughout; it was observed in some quartzites a mile below Bimphedi, which stands at the head of the valley close under the steep ridge of Chessa-garhi. This glen of Nimbua-Taur on the upper course of the Rapti is one of the most picturesque I have ever seen.

Although this Chessa-garhi range has a nearly east-west direction, parallel to the strike of the rocks to the south of it, it is formed, at least at this point, of rocks having a widely different direction. Even at Bimphedi, at the south base of the ridge, the strata strike to north 35° west. They are again thin quartzites, greatly folded and shattered, but maintaining a dominant high underlie to north-east-by-east. A little below the crest of the ridge on the northern descent, the quartzose schists are associated with strong bands of prophyritic gneiss, which is the dominant rock towards the base. The strike would take it into the ridge well within the basin of the Rapti. At the north base of the range the Pinouni river flows from the north against this mass of gneiss, and turns away to the east. Just above the bend of the river there is a cliff-section showing the crushed condition of the gneissic strata, contrasting well with the steady high underlie of the sharply bedded quartzites through which the river cuts its way obliquely. The general strike in both rocks is the same; and the whole feature suggests that the gneiss has been formed, and perhaps faulted up, along a broken anticlinal axis of flexure. It is near this line of disturbance that the copper mines of this locality occur. I was, of course, unable to visit and inspect them; but by a curious coincidence I passed at this very place a number of coolies laden with foreign copper for Katmandu, which suggests that the native resources in this metal cannot be very great. Here, and at several other places where I saw abundant refuse of old copper smeltings, the work seems to be now abandoned.

From the Sango bridge at Tamba Khoneh, along the Pinouni nearly due north to Marku, and then up the Chitlong valley to the north-east, there is an ascending section (obliquely) through the sharply bedded quartzites underlying steeply to east-35°-north. Wherever their composition is more earthy, foliation is well marked; but I did not see any gneissic band. Towards the head of the Chitlong valley the strike of the rocks becomes more easterly, up to the Chendragiri ridge, where it is east-15°-south; and the rocks are freely calcareous.

The Chendragiri ridge overlooks the Nepal valley, which is enclosed, except on the north, by rocks of the same description as those found here. There is, however, nothing like a circular arrangement of the ridges or of the rocks; the strike of both is most constant, between 15° and 25° to south-of-east; and the form of the valley is consequently most irregular—a number of longitudinal valleys, united in a central area by the suppression of the ridges, which are in some cases mere spurs running a short distance into the open; others, again, as that of Kirthipur, are nearly continuous across the valley: sometimes, as at Pashpati, the rock appears isolated in the alluvial deposits. The south-west corner of the valley divides the Chendragiri from the Phulchok range, on the same strike. Here at Kátwaldár, the Baghmati leaves the valley through rocky gorge across vertical quartzites. It is a moderately sized torrent, the watershed being confined to the ridges immediately surrounding the valley, which is only about sixteen miles long from west-north-west to east-south-east, and about twelve miles transversely, from Katawldár to the base of the Sheopuri range on the north. The alluvial area may be about 125 square miles. The elevation of Kátmandu is given as 4,500 feet. Phulchok on the south-east is the highest summit of the surrounding hills, rising to 9,720 feet.

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There seems to be scarcely any specific resemblance between the Nepal section and that in Sikhim, beyond the undoubted equivalence of the tertiary sandstones at the foot of the range. The slightly carbonaceous band at the base of the section in the Rapti valley cannot be directly identified with the coal-measure zone to the east, the associated rocks being quite unlike the Damuda sandstone, in which the crushed coal occurs at the base of the Darjiling section. Bearing in mind the great distance (more than 200 miles) between the two, it is, of course, quite possible that true equivalence may exist, but from simple petrographical comparisons, the carbonaceous schists of the Rapti would be more like the similar rock in Mr. Mallet's Daling series, over the coal band. The chief discrepancy occurs, however, in the ascending sections: in one case we find massive limestone, in the other massive gneiss. It would be idle to speculate upon the possible reconcilement of those features from such very scanty evidence. One may only notice that although the degree of metamorphism has increased from Nepal to Sikhim (if, indeed, the prevalence of gneiss does require this assumption), the degree of disturbance is far less marked in the latter area, judging from published descriptions.

It is truly vexatious to think that the settlement of questions of such wide scientific interest should be held in abeyance to gratify antiquated and barbarous official prejudices or customs. I met with the greatest civility from the few country-people with whom I chanced to come in contact. The obstructiveness is entirely on the part of those in power, who think their own dignity enhanced by exclusiveness. The officials at Katmandu were most anxious to obtain from me some useful information regarding a sulphur mine recently discovered at the base of Gosain Than mountain, in the upper valley of the Trisal-ganga, or rather in the main branch of that river that does not flow from the sacred lake; but nothing could persuade them to allow me to visit the locality. Their state of enlightenment in such matters may be judged from the fact that they imported from England a number of Davy lamps to counteract the effects of the noxious gases or vapours pervading the mine, but which I could not make out from their description to be of the nature of fire-damp. For much formal courtesy received I would offer my thanks to Sir Jung Bahadoor.

To the foregoing sketch of the older rock formations I would add a few words regarding more recent deposits. I have said that the Nepal valley contains some 125 square miles of alluvial land, but in precise language I am not prepared to say to what extent those deposits are alluvial or lacustrine. They are, on the whole, analogous to the Karewah deposits of Kashmir, as partially described by Major Godwin-Austen; but there is here no present lake, however small, to suggest a formerly more extensive water basin. The sacred myths, of course, record that the valley was once a lake, and even account in the usual miraculous way for its mode of origin; so far as I could observe, however, the oldest temples were founded during the existing phase of the surface, which is one of arrested erosion of a once continuous deposit. The feature all over the valley is flat uplands separated by broad flat valleys, locally called *Táur* and *Khola*, and corresponding exactly to the *Bhángar* and *Khádir* of the upper gangetic plains. There is much artificial terracing where the upland flats pass into the rain-wash slopes from the mountains; but I observed only one regular river terrace, that made by the actual course of the streams. Although, wherever a bend of the channel touches the edge of the upland, the side-erosion is still in progress, enlarging the area of the khola land, the rivers are not now lowering their bed. If any change is in progress, it is the reverse; the channels are very wide and shallow, and in some places at or above the level of adjoining cultivation. Such at least is the case above the gorge at Choubal; below it the channel is more confined, as occurs when a river is deepening its channel in this position the upper surface of the valley deposits must be 500 feet above the stream, which gives a minimum thickness for the formation.

There are within the valley three remarkable instances of the rivers having cut deep narrow clefts through rock-barriers. The one just referred to at Choubal is the largest, where the united drainage of the main area crosses the point of the Kirthipur ridge. There is another much higher up on the Baghmati at Gaokaran, through the point of a ridge flanking Sheopuri; and a third at Pashpati, where the Bishenmati passes through a low isolated outcrop of rocks on the strike of the Nagarjan ridge. They are mere clefts, narrower than are at all usual in the most confined gorges. One must suppose that the bygone conditions which produced them were in some manner special, and connected with the production of the alluvial basin; *i. e.*, they can hardly be accepted as remnants of the primitive channel of the Baghmati valley, before that simple feature of denudation had been converted in its upper area into a basin of deposition.

It may be presumed that the valley of Nepal is a true rock basin—that the rock-surface beneath some considerable portion of the covering deposits is below the level of the outcrop at the head of the gorge of outlet. It would seem indeed to comprise a series of such basins: if the clefts through the several ridges, as described in the last paragraph, were filled up, this would certainly be the case now; and that such has been the case there can be no doubt, for the beds now forming the adjoining terrace-land above those gorges could not have been formed had these outlets been then available. Thus the excavation of these rock-gorges by the existing rivers accounts for the present features of the valley deposits, and gives some measure of the antiquity of those features.

The fact of a rock-basin, even of considerable depth, does not involve a water-basin. This would depend upon the relative activity of the production of the barrier and of the accumulation of deposits above it, which cannot be independently determined. The question must be settled by observation as to whether the deposits are alluvial or lacustrine, and of this the evidence is not very fixed or easy of application. The degree of horizontality is one of the best tests, but needs much caution and accuracy in applying it; the slope at which true alluvial deposition may take place being so small, and there being always a chance of a very slight movement giving a tilt to originally horizontal layers. There is, indeed, sufficient evidence that some such disturbance has affected these deposits in Nepal: at several points, south of Bhatgaon and in the Kátwaldár area, along the south side of the valley, near the base of the hills, I observed dips as high as 15° in fine deposits, directed from the mountain. I could find no such occurrence in exactly similar deposits along the north edge of the basin. It would seem as if the action which originally formed the rock basin had been again, or still, at work after the formation of some of the highest beds. Major Godwin-Austen records a similar feature in the deposits of the Kashmir valley: a dip of 20° and upwards on the south and none on the north (Quarterly Journal, Geological Society, London, 1864, p. 383).

There is, however, one observation showing that at many different levels the surface at the time of formation was not a submerged one. Beds of an impure peat are of frequent occurrence. I noticed them at the lowest levels exposed in the gullies close above the Kátwaldár gorge, and near the surface of the uplands north of Katmandu, and not confined to the edges of the valley. Thin layers of the same kind occur in Kashmir; but in Nepal they are thick, and pure enough to be much used for burning bricks. Such deposits are only compatible with swamping, such as is an ordinary concomitant of alluvial conditions. There is another deposit of extensive occurrence in Nepal, and of which I find no mention elsewhere. It is a fine stiff blue-gray clay, which is very extensively used all over the valley as a manure. Although it commonly contains particles of carbonized vegetable fibre, the little organic matter in it can hardly account for its fertilizing properties. This would seem to be due to the presence of phosphate: I noticed that blue specks of vivianite are freely scattered through the clay.

It will hardly be believed that I obtained no fossils from such deposits as these. I never was near a section without having a look out for shells, and I examined several spots carefully, without any success. This may be another argument for the alluvial mode of formation of the deposits, for certainly this process is not propitious to the preservation of organic remains. In extenuation of my failure I would mention that one of our best known Indian naturalists (Brian Hodgson) was for many years Resident of Nepal; he certainly would have at least noticed and recorded the fact had he observed any in the sections that confront one in every direction. The case is the more remarkable, since Major Godwin-Austen (in 1864) describes land and fresh-water shells as abundant in the Kashmir deposits. So at least it is in the south-east side of the valley; but in his first paper on the subject (in 1858), derived from observations on the north-west side, he remarks—"in all my wanderings amongst the Karewah Hills I never was able to find the slightest trace of a land or fresh-water shell in any of the many sections I have examined." I would urge the matter upon the attention of future dwellers in Nepal. The remains of mammalia or of plants would be specially interesting; and both might be expected to turn up occasionally in such beds as the peat and the phosphatic clay.

There is no temptation to attribute the rock-basins of the Nepal valley to glaciers. Even if it were proven that glaciers had extended to a much lower level, the form and conditions here are not such as would result from or account for the existing features through that agency. The valley is not in the course of any main drainage line; on the contrary, the watershed is closely restricted to the hills immediately surrounding, none of which are of great elevation. The valley is only a local exaggeration of what has occurred generally along this mountain zone. I have said that along the strike in both directions special denudation has taken place, which I have attempted to account for by the nature of the rocks; and in both directions we find the valleys more or less filled with deposits exactly like those of Nepal. The phenomenon is longitudinal with respect to the mountain system; and can be rationally understood as the effect of compression. The local yielding might be induced by the special excavation along this zone; and the effect would be a relative elevation of the ridges on the down side, producing rock-basins. It is an illustration of a process I appealed to last year in explanation of the cretaceous rock-basins in the Garo Hills (Rec. Geol. Surv. Ind., vol. VII, p. 62).

Although rejecting the intervention of glaciers in connection with the Nepal valley, I have been much puzzled with what I took to be glacial evidence elsewhere. Etoundah stands in the Dún exactly facing the gorge of the Rapti. The ground all about is strewn with great boulders, up to 10 feet cube, principally of coarse gneiss, high and dry above the present bed of the river, in which no such blocks are now to be seen. I came to the opinion that they must be glacial erratics; although the elevation of the locality is probably well under

1,500 feet. Proceeding up the valley I did not notice any such blocks up to Nimbuatanr, where the bottom of the valley is quite choked with an accumulation of similar blocks. These I took to be a later moraine deposit. Above this they become gradually concealed, as it seems, beneath lighter detritus, over which the stream runs for some way, and which passes into a great fan-deposit stretching across the valley from a lateral gorge on the east just below Bimphedi. Here the main branch of the stream runs upon rock at a much lower level, passing by a steeply cut channel along the west side of the valley. No great blocks appear in or upon this diluvial fan.

The case was not a little complicated at first by the fact that, along the whole valley of the Rapti and up to the crest of the Chessa-garhi ridge in which it rises, no gneissic rock was observed in place. The first rock of this kind crossed on the road is some way down the northern side of the ridge. The strike of the rocks, however, would take this gneiss into the ridge east of the road well within the head-waters of the Rapti; and from this source, it must be presumed, all the aforesaid erratics were derived. The highest point of the watershed of the Rapti must be under 7,000 feet.

It would hardly have occurred to me to question the glacial origin of those immense boulders had I succeeded in finding any confirmatory evidence of glacial conditions in the higher mountain region. If the Rapti valley were ever occupied by ice, the whole country to the north must have been in a similar state. Yet I have to record that throughout the rest of my trip I failed to find any symptom of such conditions. Thinking that the valley deposits of Nepal would be younger than the glacial period, and might cover its most characteristic remains, I searched for such at the deepest point of erosion, about Kátwaldár, but without success. I was more surprised, and should have been so independently of the suggestion in the Rapti, to find no signs of glacial action in the Trisal-ganga valley at Nyakot. This is one of the great rivers, draining from the Gosain Than, a peak of over 26,000 feet in elevation, and it must now be fed by immense glaciers: yet in a length of six miles, from Nyakot to Debi ghât, I could find nothing to suggest glacial action. It is true the same excuse would apply here as in Nepal; this portion of the Trisal-ganga valley is occupied by deposits, well stratified and with peaty layers very similar to those about Katmandu, the river only touching rock at a few points; still it were marvellous that no trace should be seen of such a glacier as must have lain here had the ice ever advanced to Etoundah.

Despite all this want of confirmation, I cannot declare finally against the glacial origin of the Etoundah erratics. I know that torrents can do wonders in the way of moving large masses. But it does not appear that the Rapti can now stir such blocks as these, much less pile them together as they are at Etoundah. The great block noticed in the Churiaghati pass may be a straggler from the Etoundah rocks, though I could not see any like it on the northern slope of the range.

I trust that these crude notes will be of some service in guiding future visitors to Nepal Even incorrect suggestions may lead to observations that would otherwise have remained unnoticed.

H. B. MEDLICOTT.

*August* 1875.

# THE RÁIGARH AND HINGIR COAL-FIELD, *by* V. BALL, M. A., F. G. S., *Geological Survey of India.*

(*Second notice.*)

## INTRODUCTION.

The following account refers to the south-eastern extension of a very considerable tract of coal-measure and associated sedimentary rocks which is situated in the south-west frontier districts of Bengal, and some of the north-eastern districts of the Central Provinces. The limits and consequently the contained area of this tract are at present imperfectly known, but not improbably the latter exceeds 5,000 square miles. To the whole the name south-west frontier coal-field might be given; but for convenience in the description of certain portions which admit of separate treatment, such names as Bisrampur and Ráigarh—Hingir have been employed in previous accounts.

The name Ráigarh—Hingir was first adopted in 1871 as being less likely to mislead than the old name Gángpur,* no portion of the field being in Gangpur proper. The extension of the coal-field, as ascertained during the past season, has not rendered any further change of name desirable, the States of Ráigarh and Hingir being sufficiently centrically situated in the now known area to furnish a suitable local name; but the fact that the area so indicated is not an isolated coal-field should not be lost sight of. To the west, through Udipúr, the coal-measures or their associated rocks spread continuously to Korba in Bilaspur, while to the north, through Sirguja, the connection is unbroken up to Rewa and the borders of Mirzapur.

The Talchir coal-field,† though quite detached, is only a few miles distant from the most eastern points of our field, and may not improbably have been at one time connected with it.

The area occupied by that portion of the coal-field to be described in the following pages has a very irregular outline. Save for two narrow prolongations which extend to the east of the Ebe, it may be said roughly to commence in the angle enclosed between the Ebe and Mahanadi rivers a few miles to the north-west of Sambalpur. Thence it spreads in a north-westerly direction, the southern and south-western limit being defined by a well marked and in part faulted boundary. On the north-east, for about twenty miles, the boundary has only been partially examined, but sufficient is known of it to show that it is of an unusually complicated and obscure character. Originally it is not improbable that the extension of the Barákars was limited by the tolerably regular cliff of a low plateau of metamorphic rocks; but at the present time a considerable thickness of a newer series of rocks laps over this boundary and forms the hilly and difficult country of northern Raígarh and Hingir, thus concealing the edges of the Barákár rocks.

The reasons for supposing the Barákars not to have extended much further north are, that in a line with the bounding, uncovered metamorphics of the north-eastern corner of the field, exposures of the same rocks are found at intervals, as we proceed westwards, paving the deep-cut valleys between the ranges of upper sandstones.

How far these upper sandstones stretch northwards through Serapgarh is not known. It is possible that they conceal some small detached basins of Barákars. Thus far for twenty miles of the northern and north-eastern boundary, but for thirty miles further, until Rabkob on the Mand in Udipúr is reached, no northern limiting metamorphic rocks have been met with as yet.

* Records No. 4, 1871, p. 101. All previous notices of the field will be found mentioned in that paper.
† Described in Mem G. S. I., vol. I.

In the present account the coal-measure rocks which occupy the valley of the Mand and stretch thence to Korba are not described, as they have not been fully examined. They extend over a considerable area and contain many seams of coal.

## I.—GENERAL GEOLOGY.

The rocks which occur within and in the vicinity of the coal-field belong to the following series and groups :—

Metamorphic Series.
Vindhyan ,,
Talchir ,,
Damuda ,,
Barákar Group.
Upper sandstones or Hingir Group.
Laterite.

The rocks of the metamorphic and Vindhyan series, which surround and underlie the coal-field, are not described at present, as the examination of them has been limited to the immediate vicinity of the field, and no general exploration of them has been yet attempted.

The Talchir series does not in this area attain any great thickness. Probably 250 feet is its maximum, but this estimate, in the absence of reliable *data*, is, it must be admitted, purely conjectural.

The rocks constituting the Barákar group are, I believe, of much less thickness than in the Damuda valley coal-fields; but there are no sections which would justify any definite statement.

The upper sandstones, for which the temporary and local name of Hingir group is used without prejudice to their future relegation under one of the titles used for similar rock elsewhere, may in places exceed 1,000 feet, but that is, I believe, a fair average. It has been arrived at from the measurement of horizontal beds from the level of the Barákars to the tops of the highest hills.

The thickness of the laterite seldom exceeds 60 feet. Generally it is much less.

## II.—TALCHIR SERIES.

Within the area under description, the rocks which belong to the Talchir series do not anywhere attain any very great importance either as regards their thickness or the area occupied. As to the amount of the former, only an approximate and very rough estimate has been offered, no measurable section being exposed. Of evidence of faulting along the boundaries, except in the case to be hereafter mentioned, there is none. On the whole, it would appear that the representatives of this series merely occupy originally shallow and more or less detached depressions in the metamorphic rocks, and before any marked disturbance or denudation took place, were covered up and overlapped in most instances by the Barákars. One well marked case, at least, occurs, however, where Talchirs are immediately superposed by the upper sandstones, no trace of intervening Barákars being found.

In their lithological characters the Talchirs of this area conform closely to the well-known types, as will be seen from the following detailed descriptions.

For purposes of reference it will be convenient to refer to the several areas of Talchir rocks which occur along the margin of the coal-field by the names of the principal villages or rivers within their limits. Thus denominated they would stand under the following heads:—

SASUN—REMRA. This area occupies an irregular strip of country which stretches from a few miles east of Sasun* westwards to beyond Remra, in all for a distance of about twenty miles, and with a breadth of from three to six miles.

* Sasun is about eight miles north of Sambalpur.

In the neighbourhood of Sasun the rocks are much concealed by alluvium and laterite, and the exact position of the eastern boundary is from this cause somewhat uncertain. Both to the north and south of Sasun short sections of sandstones and shales are seen. Some of the beds of the former are tolerably thick, and one, a bluish-grey fine-grained rock, has furnished both building stone and material for vats used in lac manufacture. So far as it is seen, the boundary appears to be quite natural, following the irregular edges of the basin of deposit. West from Sasun, and on both sides of the Ebe, laterite conceals the Talchirs to a very considerable extent; though in this particular section of the country it is not abundant on the older rocks. There is sometimes, for several miles together, a most remarkable coincidence between the Talchir-gneiss boundary and the edge of the terrace-like spreads of laterite. So much is this in some places the case, that one can follow the boundary with the eye from a distance by means of the raised banks of laterite which terminate abruptly at the junction of Talchirs and gneiss. Of the cause of this I am at present unable to offer even a plausible explanation, and must therefore confine myself to the simple record of the fact.

The greater part of the bed of the Ebe, where it traverses these rocks, is one unbroken waste of sand; but there is a short section of sandstones and shales, with a dip of 8° –15° to north-north-east, at the bend near Mangalpur. Here, too, in the bed of the channel, there is a boulder bed, the boulders in which are not very numerous nor of large size, but they can be seen sticking out of the silt here and there underneath the clear waters of the river.

In the country to the west of the Ebe so complete is the covering of laterite, that exposed outcrops of Talchir rocks are only very occasionally met with. In the eastern branch of the Kadam river at Gorgoda and Bodopali, and in the western at Binki and Bolunda, there are short sections, and the existence of a spur of metamorphic rocks running into the main Talchir area is rendered apparent. Half a mile north of Binki there are seen, in the high ground, shales and thin sandstones with a dip of 30° to north-east which has been caused by some very local disturbance.

At Remra (Remda of map) there is an inlier of metamorphic rocks whose boundaries are much concealed by laterite. From this westwards, the Barákars, which first appear overlying the Talchirs at Telunpali, gradually lap over, and before Borkhol is reached all traces of Talchirs at the southern boundary have disappeared. This total disappearance is, however, probably not exclusively attributable to overlap, as the boundary appears to be a faulted one, and a portion of the originally existing Talchirs may have been cut off. In the stream west of Dagarmunda the Talchirs for a short distance dip away from the gneiss at an angle of 60°.

A small outlier from this area of Talchirs exists in the valley of the Ebe near the villages of Taldi and Terda. The rocks seen are shales and sandstone.

This area covers something under one square mile, and was in all probability, judging by the character of the surrounding country, originally, as it is now, quite detached from the main mass.

A—PUTRAPALI.—Some eight miles to the north of the strip of Talchirs mentioned above, a second spur-like eastern prolongation of the field crosses the bed of the Ebe. Although Barákars are the principal rocks seen, indications of underlying Talchirs are not wanting at the margins. The first of these is at Kirarama. The principal rock is a boulder bed which is exposed at the foot of some small laterite hills to the east of the village. The boulders consist of jasper-conglomerate, quartzite, &c., all of quite foreign origin. The boundary here is not improbably natural, the beds appearing to rest against hornblendic gneiss, a section of which is seen in the bed of the river. To the south and west the boundary is much concealed by laterite.

Apparently disconnected from this patch, Talchirs again crop out from beneath the Barákars in the bed of the Ebe below Ramesur, where there are green sandy shales with a low dip to north-east. Further east, in the village of Putrapali, sandstones come to the surface. To the north-east of that village, in heavy jungle, there is a ridge of pseudomorphic quartz which is not improbably connected with some faulting, but I failed to discover its character owing to the laterite covering. South-east from Putrapali, along the boundary, small outcrops of shales are seen at various points; and beyond Burimal, in the high ground, there are some considerable lenticular masses of limestone included in the beds of silt. Further east from this, detailed examination was not continued, but Talchir rocks were observed at Bursipali and Rurimoul.

RAJPUR.—On the northern boundary of the above mentioned spur, Talchir rocks appear in the vicinity of Rajpur, especially in the Godadia near its junction with the Baisunder, where there is a short section of shales and boulder bed, the latter resting naturally on gneiss. In the Baisunder, too, close to the junction, there are some sandstones with a dip of 5° to the south-west. In the bed of the Ebe the rocks are for the most part concealed by sand; but at Degam, on the western bank, there are short outcrops of shales and sandstones.

To the south-east, at Singaboga, some fine sandstones and shales are exposed, otherwise there are no other outcrops, and it would appear that at Chaltikra the Talchirs are completely overlapped by Barákars.

GARGANBAL.—Further north a narrow strip of Talchirs occurs on the boundary near Garganbal. The lowest bed is generally formed of arkose, as I found to be the case a little further north at Kosira on the Baisunder.* It rests naturally on the gneiss.

SAMBULPURI.—Passing now to the southern boundary of the field, a narrow strip of Talchirs is met with between the villages of Jamga and Laka. In some places, as to the south-west of Badpali, they dip away from the gneiss at a high angle. Sambalpuri is situated at about the centre of the area, and in its vicinity are the best sections. In some the beds dip at a high angle from the boundary.

A little beyond Laka these rocks are overlapped by Barákars, which are again, themselves, covered up by the upper sandstones.

Still further west is the area which may be conveniently indicated by the name of the river.

KURKET.—On the east and north the Talchirs of this area are bounded by the upper sandstones. Possibly the eastern junction may be faulted, but it has not yet been fully examined. On the west they are bounded by Barákars and on the south by gneiss. Close to Lotan there is a fine boulder bed.

### III.—DAMUDA SERIES—BARÁKAR GROUP.

In describing the Barákar rocks of this field, we have to deal with a number of detached or semi-detached areas. Those on the north have been partially or fully described in the already published report on the Baisunder and other river sections, and the area in the Mand valley, and thence westwards, has only been partially examined. As neither it nor the Baisunder section were visited during the past season, they will not be alluded to further here.

VALLEY OF THE EBE AREA.—Commencing on the extreme east of the known extension of this area, a narrow strip or spur of Barákar rocks is found in the vicinity of Lupunga, where they are horizontal and much concealed by superficial deposits. Towards the north, the junction with metamorphics, as seen at Bomali, is quite natural, the Talchirs being com-

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* *Vide* Records Geological Survey, India, 1871, p. 102.

pletely overlapped. On the south, however, there are indications all along the boundary, from Bursipali to the Ebe, of underlying Talchirs.

Proceeding westwards, the northern boundary is found to strike obliquely across a great loop bend of the Bonum river at Chalitikra, but the lowest seen sandstones there seem to be Talchirs. Between this loop and the Ebe, the country is very hilly and uneven. The rocks are coarse sandstones and conglomerates, some of the beds being of considerable thickness. As seen in the neighbourhood of the old fort of Rampur, in the Ebe section and in the country further west, some of these rocks resemble the upper sandstones of the Hingir group; but after full examination I am inclined to refer them to the Barákars. Brown hæmatite iron ore is very abundant, and especially so to the east of Ramesur. It does not appear there, however, to constitute any definite continuous bed, but to occur rather in concretionary nests and bands in the sandstones. Fragments of ore from this source spread over a considerable surface, and give the appearance of an abundant supply, especially in the valleys where they have accumulated for ages. Iron is manufactured at Chalitikra, and was formerly at Rampur, where there are still considerable heaps of slag to be seen.

Some of the conglomerates seen here consist of pebbles in a matrix which is barely sufficient to bind them together. As this matrix is often removed at the surface, the hills of conglomerate look simply like piles of loose stones, not a sign of consolidated rock being apparent. The bed of the Ebe affords no continuous section of these rocks, the few outcrops being for the most part separated by long stretches of sand. As, moreover, the beds are here horizontal, or nearly so, nothing of importance regarding their thickness can be made out. Opposite the mouth of the Bonum river, a cliff of sandstones covered by conglomerate rises to a height of from 50 to 60 feet. These rocks, though not exactly like the usual types of Barákars, from their position and physical relations, should, I think, be referred to that group. The rocks of this horizon can be traced north and south over about ten miles, from the neighbourhood of Cherla to Bograchaka; they form long low ridges with a very slight dip to the west, which carries them under the more typical Barákars containing coal and some ironstones which are about to be noticed. Between the Ebe and the boundaries of the upper sandstones underneath which the Barákars disappear, rivers and streams occur in abundance, but in two only have any traces of coal been met with.

THE LILLARI RIVER.– This river, like many others, takes its rise close to Hingir, and joins the Ebe, after a course of about twenty-five miles, near the village of Balput. Following it up from its junction, in the first two miles or so, metamorphic rocks only are seen, but beyond them Barákar sandstones are exposed, and appear at intervals up to Durlipali, where there is a seam of carbonaceous shale and coal, of which the following is the section, *descending*:—

Top denuded.

| | | Ft. | Inc. |
|---|---|---|---|
| 1. | Slightly coaly blue and black shales ... ... | 9 | 0 |
| 2. | Black carbonaceous shale with flaky coal ... ... | 6 | 6 |
| 3. | Concretionary blue shales ... ... ... | 1 | 3 |
| 4. | COAL (*Vide* Assay, p. 120) contains much iron ... ... | 2 | 6 |
| 5. | Blue concretionary shale with coaly layers towards top and bottom ... ... ... ... ... | 5 | 6 |
| 6. | Slaty carbonaceous shales, portions coaly ... ... | 3 | 0 |
| 7. | Ditto ditto the coaly portion confined to thin layers of 1-3 inches thick ... ... ... | 12 | 0 |
| 8. | Blue concretionary shales ... ... ... | 1 | 6 |
| 9. | COAL fair (*Vide* Assay) ... ... ... | 1 | 0 |
| 10. | Blue concretionary shales ... ... ... | 2 | 0 |

Base concealed.

Coal from No. 4, brought to camp, burnt indifferently, leaving a considerable ash. From No. 9, the coal is much better; a *garah* full when roasted gave out a luminous flame 18 inches long (with a 1-inch diameter burner) which lasted for an hour. Most of the residue was partially caked. Higher in the section there is a bed of tesselated ironstone which seems to be continuous at that horizon, being seen again at Choakani, five miles to the north, and also in the intervening country. North of Kodaloi there appears to be a second ironstone zone which includes a better quality of stone. This zone is also seen further south, one mile to the west of Rugonathdera. The rocks throughout this region are much concealed by laterite.

Seam.

Two miles further up the stream, near Khairkoni, the top 2 feet of a coal seam are exposed. For four miles further, up to Chamri-mahal, the bed of the river discloses a much broken section of sandstones and carbonaceous shales, which in places roll slightly, but are otherwise horizontal. Beyond this the sandstones of the Hingir group are alone found.

Seam.

Bagdia River.—About half a mile from Ailepur (Lakenpur) the top of a seam is seen in the river. Owing to water and shifting sand I could do no more than prove the existence of at least a foot of fair coal which burns freely, leaving a flaky ash. What the total thickness of the seam may be it is impossible to say at present. In the country to the east there are some ridges of ferruginous sandstones which may, perhaps, be in part prolongations from the main area of upper sandstones, but I was unable to separate them from the underlying Barákars with any degree of certainty. Leaving for the present the description of the strip of Barákars which extends from this neighbourhood through Borkhol along the south of the field, that which occurs along the north-eastern boundary may be most conveniently disposed of. Close to Ratakand, a small village on the Godadia, the Barákars, which further south are covered up by the sandstones of the Bilpahari range reappear, and form an irregular strip which is continuous up to the Baisunder, where the coal-measures, described in the previously published notice of this field, occur. On its eastern side, the Barákars occupying this strip rest naturally upon the metamorphic rocks, an arkose bed being not unfrequently found at the base. On the western side the irregular outline formed by the foot of the upper sandstone highlands of Hingir constitutes the limit of exposure. In the river at Dúlúnga, to the south-south-west of the village, there is a coal seam of which the following is a section of the portion seen, *descending*:—

Seam.

| | | Ft. | Inc. |
|---|---|---|---|
| 1. | Black and grey shales ... ... ... | | 10 |
| 2. | Hard stony COAL ... ... ... ... | | 6 |
| 3. | Flaky COAL ... ... ... ... | | 2 |
| 4. | Grey and black shales ... ... ... ... | | 4 |
| 5. | Flaky shales, coaly in parts ... ... ... | 1 | 10 |
| 6. | Blue and grey shales ... ... ... ... | 1 | 0 |
| 7. | Stony COAL and black shales ... ... ... | 1 | 4 |
| 8. | COAL ... ... ... ... ... | | 4 |
| 9. | Stony COAL and black shale ... ... ... | | 7 |
| 10. | COAL ... ... ... ... ... | | 7 |
| 11. | Shale ... ... ... ... ... | 1 | 4 |
| | | 8 | 10 |

Further down the stream some higher layers of carbonaceous and coaly shale belonging to the same seam are imperfectly exposed.

To the north of the village there is a seam seen, at the road crossing, which contains about six feet of coaly shale and coal, the dip being 5° to south. In the section of rocks below this, that is to say, further up the stream, the boundary is seen to be perfectly natural; gneiss being exposed in the bed and sandstone in the overhanging banks. From this northwards the relations of the rocks are for the most part obscure and the western boundary is very intricate. In the Barákars to the south of Kiripsira, black shales and ironstones occur. On the Garganbal and Bagbura road, east of the boundary, in the first stream crossed, there is a bed of arkose which seems to be detached from the field. Beyond it for the next mile or so, the granitic gneiss rocks which occasionally appear are much covered by loose boulders which in their miscellaneous and foreign character resemble those found in the Talchirs. In all probability they were derived from a Talchir boulder bed of which no other trace is left now.

SOUTHERN BOUNDARY.—Passing now again to the south boundary at Borkhol. In speaking of the Talchirs it has been pointed out that they disappear on the boundary at this point, being much overlapped, and having probably been in part cut out by a fault which appears to have formed the present southern boundary and limit of the field. At Singapur the area occupied by the Barákars does not exceed about half a mile in width, and as they rest nearly horizontally on Talchirs, the evidence of extensive overlap by the upper sandstones is complete. West from Borkhol, where the Talchirs are not found on the boundary, their apparently diminished thickness might be attributed to the fault having cut out lower beds, but here it is quite clear that, unless there has been great natural and original thinning out of the upper beds of the Barákars which are seen in the Ebe valley, their edges must be completely overlapped by the upper sandstones.

From Borkhol the faulted boundary runs in a steady north-westerly direction for nearly forty miles, and with it for thirty miles, a valley which presents a wonderful degree of uniformity throughout. On the one side, outside the fault, are ranges and sometimes low ridges of metamorphic or other old rocks, on the other the scarp of the sandstones forming the Hingir plateau. The bed of this valley being coincident, or nearly so, with the base of the upper sandstones, the Barákars, and sometimes the Talchirs, form the floor. Although many rivers and streams cross the valley at right angles, there is such an accumulation of superficial deposits, that sections, showing the character and relations of the rocks are of extreme rarity. The bottom of the valley, almost throughout, may be described as one succession of *paddy* fields. The origin of this state of things is quite obvious. The valley, in the first instance, scooped out by lateral streams along the faulted junction, has subsequently served as the repository of the solid substances brought down by the rivers, which, coming from the highlands of comparatively soft sandstones, find themselves suddenly arrested by the metamorphic rocks through which they have only been able to cut narrow gorges.

At Borkhol itself no rocks are exposed in the valley; but further west, south of the village of Durga, sandstones and gneiss are seen in close proximity to one another, though no actual contact is exposed. To the west of Kutrapali there are some ferruginous Barákar sandstones with ironstones, which also extend northwards up into a bay to the north of the village. Proceeding in the same direction the same rocks are met up to Dibdorah, with the addition, at that place, of coal which crops out underneath the waters of the Hingir river. An excavation which I had made in this seam proved a thickness of at least 6 feet 6 inches down from the denuded surface. Of this thickness, all, except the lowest foot, consists of very fair-looking coal. So far as appearance goes, it is certainly the best which I met with in the field. The dip is about 5° to north-20°-east, or from the boundary. What the total thickness may be I had no means of ascertaining.

Seam.

Higher up the river, close to the foot of the falls over the upper sandstones which are described on a following page, the Dewan of Kodibuga pointed out to me some fragments of carbonaceous shale which he said had been there for several years. Whence they came I am quite uncertain. There may possibly be a seam at the foot of the falls covered up by water and fallen blocks. Certainly in its higher reaches the river does not cross any Barákar rocks, and I found no trace of carbonaceous matter in the stream above.

Between Jhargaon and Dibdorah, the sandstones, wherever seen near the boundary, as also the coal at the latter place, exhibit no trace of great disturbance at their edges, having, apparently, when faulted, gently subsided into their present position. Neither at Dibdorah nor Jogidhipa are junctions disclosed by the rivers. Between Dibdorah and Jogidhipa the Barákars are of the same character as those between the former and Jhargaon.

At Jogidhipa, the scarped hills, which further east marked the limits of the upper beds, locally die away, and physically it seems possible that the rocks exposed for some distance to the north might be Barákars, but lithologically they appear to belong to the upper group.

Continuing along the valley we find at Lipuspali, north of the village, dark colored sandstones which appear here to form the base of the upper series. No Barákars are seen, though they doubtless exist under the alluvium. Before reaching Manwapali, Talchirs are found to come in again, forming a narrow strip along the boundary and leaving but very little room for the Barákars to occupy.

In the Supnai west of Bhogra (Basunpali of map*), at the base of the section, there is a short thickness of sandstones, apparently Barákars, which dip from the boundary at an angle of 30° to north; the overlying rocks, too, are also locally disturbed. Between Bhogra and Sumbulpuri the position of the Barákars is marked by ironstones, which are seen near the village of Badpali. At Sumbulpuri, if the coarse grits seen in the river section dipping at angles of from 30° to 45° from the boundary be not referable, as seems probable, to the Barákars, then that group must be here reduced to very narrow limits. At Danot the upper rocks come close to the north of the village, while Talchirs crop out on the south; but there is room for a small thickness of Barákars. In the Kelú section between the gneiss on the one hand and brownish-red upper sandstones on the other, a concealed interval affords room for both Talchirs and Barákars. One short outcrop of Talchirs is seen close to the road crossing.

Had I not known something of the upper reaches of the Kelú, the occurrence of fragments of coal in the bed of the river, as it issues from the upper sandstone hills, would have been a puzzle involving much fruitless search. It is evident that these fragments have travelled from the seams which the Kelú traverses far to the north near Tamar and Jhargaon.

Between Laka and Cheripani, an interval of only about 150 yards exists between these upper sandstones and the Vindhyan quartzites. In this interval laterite and a recent conglomerate are the only rocks seen. Further west from this I did not meet with the slightest trace of Talchirs, and the lowest sandstones seen are not, I think, Barákars, so that both series are again most probably cut out by the fault which hence westwards runs between quartzites of Vindhyan age and the sandstones of the Hingir group.

GARJAN AREA.—To the north, under the Garjan hill in Hingir, some carbonaceous rocks, probably Barákars, are exposed in the streams. This area has not been examined as yet in detail.

NORTHERN RAIGARH AREA.—This is an area of Barákar rocks of which upwards of 200 square miles have been examined. It is situated in the north-eastern corner of

* The names of all the villages in this part of the valley are misplaced on the map.—(Atlas Sheet).

Ráigarh. *On the east, south and west it is surrounded by hills formed of the upper sandstones, under which the coal measures pass.*

To the north the limits have not yet been ascertained, but from the sections which have been examined, and from the general physical structure of the country, it is probable that, with a few exceptions in the valleys, where contacts of the Barákars with the underlying metamorphics are exposed, the edges of the former are overlapped by the upper sandstones.

In this central area, the Barákar rocks, which from their position are probably the top measures of the group, differ materially from those met with in the Ebe valley to the east. Instead of coarse sandstones and conglomerates, there are fine sandstones with much carbonaceous shale and some coal. In all probability the coarser rocks occur below, and indeed to the north some of them are seen cropping out towards the boundary. In the Baisunder section†, on the other hand, it would appear that the coarser rocks never were deposited, as only a small thickness of sandstone and arkose intervenes between the carbonaceous shales and gneiss.

In the western part of our area the Karket river collects the drainage and affords tolerable, though much interrupted, sections.

Karket River Section.—That portion of the Karket which traverses the upper sandstones will be found described on a following page. In so far as the Barákars are concerned, it is only necessary to describe the descending section which is exposed between Báiámundá and Karamakel.

The highest rocks seen are some sandstones with three bands of carbonaceous shale, which measure respectively 2'., 3'. and 3'. 6.", the dip being 5° to south-west, which carries them under the horizontal upper sandstones. Some ironstones seen to the south of Báiámunda, but not exposed in the river section, not improbably constitute the top beds.

Not far from the mouth of the Katang stream the top of a coal seam is exposed which measures about one foot. For about half a mile north of the Katang there are massive sandstones, the relations of which to the more typical Barákars are somewhat obscure: at first it appeared probable that they might be upper beds resting in a flat synclinal, but subsequently seen cases of similarly situated and similar rocks, suggested that they were only locally interpolated beds.

Beyond these again there are thin bedded sandstones with shales more or less carbonaceous, having a low dip to south. Less than half a mile to the south of Suadera there is a coal seam which contains only eight inches of good coal with a dip of 5° south-west.

Seam.

From this up to the mouth of the stream which rises in the Duldulla H. S., the only rocks seen are thin bedded sandstones and carbonaceons shales, which vary a good deal in the direction of their dips on either side of south, but not much in the amount, never ranging above 10.° There is nothing that can be called coal exposed in this portion.

At the stream, however, there is a seam of which the following is a section:—

| | Ft. | Inc. | |
|---|---|---|---|
| Massive sandstone, about ... ... ... ... | 25 | 0 | |
| Shale ... ... ... ... ... ... | | ? | |
| Coal ... ... ... ... ... ... | 1 | 7 | |
| Shaly parting ... ... ... ... ... | 0 | 9 | |
| Coal ... ... ... ... ... ... | 0 | 5 | |
| Carbonaceous shale with coaly layers ... ... ... | 4 | 8 | |
| Coal ... ... ... ... ... ... | 3 | 0 | seen. |
| Base hidden; dip 3° S. S. E. | | | |

† Records, Vol. IV, pt. 4, p. 105.

The overlying bed of sandstone is seen lower down the river to break up into several smaller ones in consequence of the interpolation of carbonaceous shales: thus bearing out the view taken above of the bed seen near the mouth of the Katang.

Further north from this I did not continue detailed examination, but fragments of coal are abundant from the higher reaches, and the Barákars extend at least as far north as the valley surrounding Kurmukel (sheet 59 *a*, old series).

In the Katang stream, from Kassia to its junction with the Karket, there are carbonaceous shales with sandstones, and the massive bed previously mentioned. Some fragments of coal were seen, but no exposed seam could be found.

*Throughout the country between the Karket and Pazar the rocks are much covered, and there is nothing of particular interest to be noticed.*

PAZAR RIVER SECTION.—At the junction of the Barákars and upper sandstones, where this river enters a gorge through the hills to the south-west of Kasdol, the former show signs of local disturbance, and the bed, which is a few feet from the junction, dips away from under the overlying horizontal sandstone in a manner which is suggestive of unconformity. There being no actual superposition, this section cannot perhaps be considered conclusive, and causes other than original unconformity may have produced the present appearance. Taken in conjunction, however, with other evidence of unconformity to be given further on, this section assumes some importance. A short distance up the stream there is a seam of which the following is a section:—

| | Ft. | Inc. |
|---|---|---|
| Sandstone ... ... ... | 0 | 6 |
| Shales ... ... ... ... | 7 | 0 |
| COAL ... ... ... ... | 1 | 5 |
| Black shale ... ... ... | 0 | 5 |
| COAL ... ... ... ... | 1 | 0 |
| Shales, portions coaly. | | |

For the remainder of this section up to Pondripani there are fine sandstones and carbonaceous shales, the latter with occasional layers of coal, as at Putrapali (8″) and at Pondripani (2″). There is much false bedding and interpolation in this section. In the Digi stream the section is similar. A seam of 6″ of coal is exposed at Deogur. The Kelu river section up to Tamnar also exposes the same kind of rocks with no coal of workable thickness.

The Kelu section beyond this up to Khara was described in my previous report. Resuming, therefore, at that place, we find that for nearly two miles hardly any rocks are seen, but beyond that there is a tolerably continuous section of sandstones and carbonaceous shales The first seam measures, descending, dip 5° south-west:—

| | Ft. | Inc. |
|---|---|---|
| COAL ... ... ... ... | 6 | 0 |
| Shales ... ... ... ... | 3 | 6 |
| COAL ... ... ... ... | 1 | 0 |

The coal is probably of rather inferior quality, but in its weathered and water-logged condition it is not possible to form a conclusive opinion. The next seam of any importance measures about 17′. The coal is in thin layers of less than a foot, alternating with shale, dip south-south-west. Beyond this there appear to be some other seams; but they are not well exposed. North-west of Pelma two flat seams are exposed. Their thicknesses seem to be about 6′ and 4′ respectively. The coal may be of fair quality. These seams are also seen in the broken ground east of the river, where the thickness may be somewhat more. For three miles further I followed this section (into Sheet 52), the Barákars continuing steadily in the bed of the river, while the hills on either side were of the upper sandstones. Fragments of coal were still to be seen at the furthest point reached; but from the abundance of gneiss and jasper-conglomerate pebbles, the metamorphic rocks cannot be very far distant. The jasper may not very improbably be derived from Talchir beds.

The Pelma-Milupara valley is one of several along this frontier where denudation has removed the upper sandstones, thus forming a vast amphitheatre in which Barákars form the floor. A considerable accumulation of alluvium occurs in this valley; it is much cut up by ravines, and consequently difficult to traverse. As it was impossible to take the camp beyond Milupara, much time was wasted in going to and fro. To draw a satisfactory boundary at the foot of the hills would require close and very detailed examination.

BENDIA RIVER SECTION.—In the portion of this river not previously examined,* between Kornkel and Janjghir, for the first three miles the rocks are much covered, after which there are coarse sandstones with a succession of seams containing coal in bands of from 2′ to 3′. None of these seams are well exposed, as they are for the most part flat, and it is impossible to speak decidedly of their value. It is not, however, at all improbable that good coal in workable quantity may exist. At Janjghir the Barákars abut against gneiss, and are in places covered by upper sandstones which cross the boundary. In some cases the bottom beds resting on the gneiss in the Janjghir valley may be Barákars; but the cases are doubtful. To the west of the village a pebble conglomerate bed can be traced from off the metamorphics on to undoubted Barákars upon which it appears to rest unconformably, but the section is not quite clear. In one place in the river it is seen distinctly overlying a coal seam with associated Barákar sandstones. This seam measures—

| | Ft. | Inc. |
|---|---|---|
| COAL, about ... ... ... | 0 | 8 |
| Parting ... ... ... ... | 0 | 3 |
| COAL ... ... ... ... | 1 | 0 |

I think the conglomerate must be referred to the upper series.

In the bed of the stream on the hill side, at the head of this valley, I found some fragments of black shale, which appear to have come from the upper beds. As will be noticed further on, a similar case occurs to the east, in the valley of the Bendia.

From the preceding it will be seen that there are no *data* sufficient for forming an opinion as to the total thickness of the Barákars, but that there is strong evidence of great irregularity of deposit.

On the prospects of coal being found in useful amount, I shall speak in the section on economic resources.

## IV.—UPPER SANDSTONES, OR HINGIR GROUP.

Resting upon the Barákar rocks is a group of beds differing from them in their lithological characters, and containing certain fossil plants which have in no part of the country been found to occur in rocks of the Barákar horizon.

With rare, and perhaps even somewhat doubtful exceptions, this group does not include any carbonaceous deposits. In the fossil plants the carbon has been all removed and replaced by iron.

In some of the sections described on previous pages evidence is given of the extensive scale in which the Barákars have been overlapped by these younger rocks, At many places along the southern boundary of the field, as, for instance, at Singapur and Borkhol (*vide* p. 108) the area occupied by the Barákars is reduced to very narrow limits. Again, near the Kurket

* Vide Records, 1871, pp. 105-6.

these upper rocks rest immediately on Talchirs, and along the northern boundary not unfrequently upon gneiss.

Unconformity.

Although the junctions between these rocks and the Barákars often appear to be quite conformable, certain observations seem to indicate that some unconformity between the two does exist. No actual section exhibiting unconformable superposition can be adduced, however. The nearest approach to it is perhaps the case above mentioned, where, close to Janjghir, a pebble conglomerate was traced off the gneiss on to Barákars upon which it appears to rest unconformably, but owing to some false bedding, the section is not quite clear, and should not, perhaps, be regarded as crucial. In the Pazar river section (page 111) there is the already noticed case of disturbed Barákars occurring close to the junction with the massive horizontal upper sandstones.

Passing from these individual cases, which afford evidence of only doubtful value, to the more general relations existing between the upper sandstones and the Barákars, we find that, taken as a whole, the latter exhibit an amount of rolling and disturbance of which the upper beds show no trace whatever.

The great amount of false bedding in the Barákars, noted both in this and the previous report, and the overlap, are quite sufficient to account for the fact that the beds of Barákars appearing from underneath the sandstones vary much in character in different parts of the field. At Lipuspali, for instance, there is a coal seam only a few feet below the red shales. Yet no sign of this coal seam appears in any other section. But when the facts observed in the tract of country indicated as the northern Ráigarh area (p. 109) come to be examined, it is difficult to imagine any cause other than unconformity as being able to produce the relations which exist there. Denudation has in that part of the country cleared away the upper rocks and formed an extensive basin where upwards of 200 square miles of Barákars are exposed. Numerous more or less continuous sections of these rocks are afforded by the rivers which run from north to south; but the best is that in the Kurket. In that river from south to north there is a steadily descending section, which is sometimes complicated by local rolls, but which must represent several hundred feet in thickness. The crumpling and rolling and the dips,—the latter in places attaining as much as 10°—are incompatible with the idea that these beds are merely in their original position of deposit on a sloping surface. Several of the coal seams dip at angles of 5,° which, small though it be, can scarcely have existed at the time of deposit. From its very nature and generally accepted origin the coal must have been at first horizontal, or nearly so.

In the surrounding rocks which form the ranges limiting the basin, and in three inlying hills or groups of hills known as Gid, Duldulli, and Kolam, no evidence of similar rolling and crumpling is apparent, while the sections, so far as they go, induce the belief that these outliers rest on the edges of different portions of the Barákar succession. From the interpolation and false bedding, which, as has been alluded to, characterise these Barákar rocks, no actual conclusion could be drawn from observations on the difference in charactar of individual beds which are immediately covered by the upper sandstones. Indeed, the overlap alone would be sufficient to account for such differences as have been observed. It is therefore necessary to confine the evidence for the unconformity to the more general characteristics of the two series, all small sections being, for the above given reasons, unreliable.

Examined closely, the upper sandstones exhibit no signs of disturbance and appear to be quite horizontal. On some of the scarped ranges where the view takes in several miles, a slight southernly trend can, however, be made out, but no rolling corresponding to that in the Barákars at the base. Whether the rolling and crumpling in the thin beds is in any degree due to the pressure of the great mass of hills—which would in that case have been produced

I have been unable to see that the beds of different lithological characters occupy any definite succession. The red clay beds particularly seem to have a very capricious distribution. Though not always present, they are generally found among the bottom beds of the group. *Towards the top, too, they not unfrequently occur. In the centre they appear seldom. Often where one would expect to see them, they do not show the slightest indication of their presence. Conglomerates and sandstones alternate with one another without showing any regular sequence so far as I was able to make out.*

The conglomerates consist chiefly of small rounded quartz pebbles, bound together in a sandy ferruginous matrix with a varying amount of felspar. The pebbles rarely exceed 6 inches in their greatest diameter, and sometimes they are uniformly, throughout particular beds, not larger than small marbles. Occasionally the pebbles are of gneiss. This is, of course, most frequently the case when the underlying rocks belong to the metamorphic series.

The sandstones vary much in texture and color, but really fine-grained sandstones are rare, and white, or even grey looking, rocks are of unusual occurrence. Sometimes beds occur, both in the case of conglomerates and sandstones, which it is not easy to distinguish from Barákars. In such cases traces of associated carbonaceous beds are anxiously looked for as affording an almost infallible test of the age. The beds of sandstones, as may be seen in the scarped sides of the hills, occasionally attain very considerable thicknesses, narrow partings of shale occurring at distances of from 20 to 40 feet. The most common form of sandstone is a rough brownish grit, which, even when under the constant action of running water, seldom shows a clean or smooth surface. Carbonate of lime is not often present in sufficient quantity to give rise to any marked form of chemical weathering. Mechanically formed pot-holes are, for some reason which I cannot explain, less common than in the Barákars.

Shales or clays, generally red and sometimes passing into ironstones, include all the remaining forms of rock found in this group. In one direction these beds show a tendency to pass into sandstones, but as I have said, fine grained sandstones, properly so called, seldom occur. Mica occurs in abundance in certain layers. With the exception of some white beds which are occasionally met with, all are ferruginous, some highly so; the latter are dense and heavy, but are seldom used as an ore of iron by the natives.

The only beds of this group which have so far proved fossiliferous are the shales which have just been mentioned, and they are by no means universally so. The place where I found fossils most numerous as regards individuals was in the Garjan hill in Hingir. Here, too, the number of species was the greatest, but it does not altogether exceed eight.

The following is a preliminary list by Dr. Feistmantel:—

EQUISETACEÆ.

Schizoneura ? = Damuda sp.
" ? sp.
Vertebraria Indica, *Bunb.*

FILICES.

Glossopteris Indica, *Schimp.*
" Browniana, Brogn. Var. Australasica.
" Sp.?
Pecopteris Sp. = Bunbury's drawing.
" Lindleyana, *Royle.*

The specimens of Vertebraria were met with at Girundla, Kodaloi, and on the Bilpahari.

The question of the correlation of these rocks with the groups elsewhere known in India is for the present reserved.

These sandstones cover by far the largest part of the area included in the field. Throughout the central portion no other rocks are met with, and to the north-east and south-west, only narrow strips of the older rocks are disclosed at the boundaries, and that for comparatively short distances. In the northern part of Ráigarh there is a considerable exposure of Barákars which is surrounded on all sides by these rocks, and so superficially separated from the Barákars of the Ebe valley on the east, and of the Mand on the west.

The eastern boundaries of these sandstones follow an irregular outline, which is in general well marked, and is more or less coincident with the limits of the hilly plateau country of Hingir. Possibly there may be some small outliers within the limits of the area colored as Barákar, but the often highly ferruginous characters of some of the pebbly beds presumably belonging to the latter, and the obscurity of the physical relations renders discrimination almost impossible.

The group of hills of which Sitaram and Bilpahari are the culminating points is situated at the northern extremity of the eastern boundary; the rocks seen there are sandstones and red shales, the latter containing *Vertebraria.* Some of the sandstones are highly ferruginous, and contain layers and plates of hardened and dense character which weather out on the surface into relief, as is commonly seen in the Pachmari sandstones.

At Girundla and Bindichua the same rocks prevail; they are generally horizontal, but at one place in the Lillari, south of the latter village, some local disturbance has given rise to a southern dip. The Bindichúa G. T. hill station well illustrates the tendency of certain beds of sandstone to weather into curious and grotesque shapes.

The rocks about Onkilbira, Komghat, and Pikol are all of the same character and call for no particular notice. The same may be said of those forming the hills to the east and south of Lakenpur.

Close to Borkhol, the Koilar river debouches from the hills; it is the first of a series which, rising in the highlands of Hingir, pursue a steady south course to the Mahanadi. As the rocks which they traverse, except near the boundary, are horizontal, the sections do not throw much light upon the general characters of the series. Ordinarily these rivers run in deeply cut channels in beds of coarse brown or red sandstones. These being water-bearing strata feed the rivers all along their course, and the moist faces of exposed rock are the favorite growing place of a species of *Drosera*; all these rivers are perennial, and their constant flow of water makes them contrast with the rivers of the gneiss and Talchir areas which soon dry up after the rains, leaving wide sandy channels.

The general characters of the valley which extends along the boundary in a north-westernly direction from Borkhol have been described on a previous page. With the rocks which bound it on the north only have we to do at present. North of Jhargaon the road to Raini ascends over the scarp of red shales and sandstones; these are still better seen further west at Dibdorah, where there is a step in the Hingir river over which the waters fall, forming a most picturesque, and in the eyes of the natives sacred, cascade. Near the foot of this fall, as has already been mentioned, some pieces of carbonaceous shale were found, but none above.

At Jogidhipa the physical features are somewhat modified, as there is no distinct ridge or scarp on the Barákar boundary, but the relative position to the main boundary of the field appears to continue the same. From this westwards the red clays cease to occur associated with the basal rocks of the upper sandstones.

In the Kur or Chota Kelú, between Berapali* and Beramunda, there are brown and yellowish sandstones which sometimes contain pebbles, but there is no trace of the red clays. Their absence may be due to overlap of that portion of the series in which they occur; but I think more probably they were never deposited here. At Jamga* the Barákars are almost completely covered up by these upper rocks.

In the Supnai section from a point east of Jhargura to Bhogra* there are coarse ferruginous sandstones which are at first slightly inclined to the south, but as the boundary is approached, they dip in the opposite direction, and the bottom beds, some of which seem to be Barákars, dip at an angle of 30° to north.

In the Somkara and Bilaijor rivers to the east and west of Sambulpuri there are similar sections; in the latter the rocks close to the boundary dip away from it at as high an angle as 45°. Close to Badpali there are some traces of a local bed of red clay.

In the Kelú there is a long interval between coarse sandstones dipping at 20° north and the gneiss. Save for a small outcrop of Talchirs at the ghât there is nothing to indicate the character of the intervening rocks. Further north, these sandstones fall to the horizontal and are deeply channelled by the river. I have on a previous page indicated the origin of the coal fragments which are seen in the bed of this river.

At Donot, the edges of the upper sandstones form a distinct and prominent ridge close to and north of the village.

In the vicinity of Cheraipani the Talchirs and Barákars are apparently finally overlapped by the sandstones on one side, and cut out by the fault on the other; at least no certain sign of them is met with further west. They may exist, however, at the bottom of the narrow alluvial valley which is bounded by on either side quartzites and sandstones. At Delari (or Derali) sandstones dip at 30° to north-east. Just north of the village the lowest bed may possibly be Barákar, but I think not. To the south-east of the village these sandstones are seen within 200 yards of the quartzites.

From this westwards to the Kurket, and also to the north in the direction of Tumardi, the rocks which are exposed all belong to the upper series.

KURKET RIVER SECTION.—At Rabo there is an interval of perhaps 300 yards between the gneiss and some beds of sandstone, which dip at an angle of 30° to 30° north-of-east.

* These names, as previously mentioned, are all misplaced on the Atlas Sheet.

What may intervene between these outcrops can only be conjectured, possibly Talchirs, but there is no trace of them to be seen. With regard to the sandstones, I think they must be referred to the upper series, though they are not unlike Barákars, which, indeed, I thought them to be when I saw them in 1871. The high dip is gradually lessened, until about a mile further north the beds become horizontal, and so continue with only local variations in dip for about five miles. In places the river runs in a deep cutting with walls twenty feet high. The sandstones are of the usual character, coarse ferruginous, sometimes with plates and layers of more highly ferruginous composition. They are often somewhat conglomeratic and not unfrequently pinkish in color. There is no sign of red clays in this section. From underneath these rocks at Baiamunda, as has already been mentioned, appear the Barákars.

To the west the boundary, leaving the river, passes along the foot of a range of hills which strikes north from Katangdi. At Nowagaon (Nowagud) these hills present a scarped face of coarse ferruginous sandstones with some red clay partings. These rocks have a general, though slight, dip to the south. Detached from this range, towards its northern extremity, is the Duldula hill which is formed of the same rocks.

The eastern boundary on leaving the Kurkot, passes south of Baiamunda and then bends southwards to Jiringol. Between Balumar and Samaruma the red shales were again met with near the base of the series.

The Gid hill appears to be an outlier of these rocks, the continuity being broken on the south, but this is not quite certain, as the rocks are much hidden in the broken raviny ground. The principal rocks forming this hill are ferruginous sandstones and red shales, but at the base there is a considerable bed of white sandstone of doubtful affinities.

The character of the junction in the Kelú river section has been alluded to above; the upper sandstones, away from the boundary, are horizontal, or have a gentle dip to the south.

From this eastward as far as the Ambo hill the boundary runs along the foot of the scarp; this is well seen at Deogaon and Pariga. In the Garjan hill, I found the principal part of the fossils mentioned on page 115. The further extension of these rocks to the east has been noticed in my previous report, and it therefore only remains to describe their occurrence to the north so far as they have been examined in that direction.

At Janjghir and the valleys on either side of it, we find Barákars abutting against gneiss, the boundaries being more or less overlapped by sandstones and conglomerates which form the surrounding hills. These sandstones and conglomerates are, I think, referable to the upper group, but at the heads of two of these valleys, from 150 to 200 feet above the level of the top of the Barákars seen outside, I met with fragments of coaly shale in the beds of the hill-side torrents. At first sight this suggested the probability of Barákars occurring at the higher level, but another case, presently to be mentioned, seems to make it probable that carbonaceous shales do sometimes occur in the upper beds.

A glance at the map* will show the difficult nature of the country where these observations were made. Until the whole of the hill tract there has been examined, it will be impossible to speak with any degree of certainty on the subject. As rendering it more probable that the carbonaceous shale is from the upper sandstones, it may be mentioned that the fragments were much mixed with pieces of red shales which *may*, however, have come from a higher level.

The amphitheatrical appearance of the valley of the Kelú above Milupara has already been alluded to. Owing to the jungle and superficial deposits, the bonndaries are much obscured, but at Hingjhar there are exposed some ferruginous sandstones and red shales

* On the one inch to a mile scale. In the accompanying sketch map the hill shading has been omitted.

resting upon ironstones, which latter are presumable Barákars. On the east of the valley, in the Sukti hill, there is a good section of these rocks.

Ascending from the village of Bajarmura, which is on red clays and sandstones, the path passes over whitish grey sandstones, which might pass lithologically for Barákars; above them near a bear's cave* is a band of black shales; this is at least 300 feet above the red shales of Bajarmura, and must therefore belong to the upper series.

Above this there were coarse ferruginous sandstones which continued up to the top of the hill. On the eastern side of the hill, at Khara, the Barákars extended up the side from 100 to 150 feet.

So far as they have been examined, these upper sandstones appear to constitute one group which is not susceptible of any natural sub-division.

## V.—LATERITE.

In the course of the preceding pages the occurrence of laterite resting upon the older rocks has been occasionally alluded to. It is more particularly abundant on the Talchirs, and, as noticed on a previous page, its limits are curiously concurrent with the Talchir—gneiss boundary in the eastern part of the field. To the north-east it is often found on gneiss, so that its occurrence in one locality in a limited way on the Talchirs only is the more remarkable. It seems to be chiefly, if not entirely, confined to the lower levels, and I never found a trace of it on the higher hills, though in such positions it is commonly met with in Sirguja.

There is nowhere, so far as I know, a greater thickness of it than about sixty feet. In the eastern part of the field it forms wide spreads, which completely conceal the underlying rocks. In lithological characters this laterite resembles the laterite of Midnapore and elsewhere.

## VI.—FAULTS AND DYKES.

The character of the south-western boundary having been described in the previous pages, little remains to be said, and recapitulation is, perhaps, unnecessary. Although no single section can be pointed to as absolutely establishing the faulted nature of this boundary, still the general tendency of the observations which have been made is to point in that direction, while the difference in the character and age of the beds which are successively brought into conjunction, and the remarkable straightness of the boundary, are strongly corroborative of the same view.

With this exception there is no evidence of any faulting throughout the area, and most of the boundaries have been distinctly seen to be natural.

*Dykes.*—But one case of trap also has been met with in the field; this is at Kirarama in the Barákar area, where a dyke is exposed for a few yards. A similar rock is seen at Kondaimunda, in the gneiss, and the two may be continuous. It must be noted that there is a possibility of this being only the peak of a trap-like metamorphic rock which strikes up through the Barákars. Its lithological characters quite favor this possibility.

## VII.—ECONOMIC RESOURCES.

The economic resources of this field are—Building materials, Coal and Iron.

BUILDING MATERIALS.—As in other coal-fields containing Damuda rocks, many varieties of sandstones occur which would be applicable to building purposes. Hitherto the only

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* NOTE.—The cave is in a friable bed of slightly ferruginous sandstone, which I noticed was perforated in a peculiar manner. On examination each of these perforations, at least those which looked freshest, contained the nest, or rather den, of a small spider, while the older ones contained exuviæ of spiders.

It was perfectly obvious that these perforations, which were mostly ¾ of an inch deep, had been made by the spiders by patiently removing the friable rock grain by grain.

rocks which have been used in this way are the Talchir sandstones of Sasun. These furnish a suitable material for copings and similar purposes in Sambalpur. Recently they have been employed in the manufacture of washing vats for lac works. The building stone which is chiefly used in Sambalpur is a schistose quartzite which is found in the station. Limestone of limited amount, but good quality, occurs in the Talchir rocks to the south of Luponga (*vide* p. 105). Kankar is found in most of the alluvial tracts, but is not generally abundant. The Vindhyan rocks south of Padampur on the Mahanadi include an excellent limestone, which is the source of lime chiefly resorted to in the district.

COAL.—The seams which are exposed in the portion of the field at present under description are neither very numerous nor individually of promising quality; but it must be remembered that the coal-measure rocks are not only, as a whole, very slightly disturbed from their original horizontal position, but are much covered by superficial deposits, and that there is a complete want of sections which might show the succession of beds constituting the group. The true, or even approximate, value of the field, therefore, can only be ascertained by borings. In the meantime it may safely be asserted that there is a fair prospect of this field proving to be of considerable value.

Of those seams which are at present exposed I should recommend that at Dibdorah as being the one which is most likely to reward exploitation. The advantages which this seam possesses are the following:—The coal is of fair quality, much better probably than might be supposed from the assay, the sample having been taken from under water; the thickness is at least six and a half feet. The seam being at the surface, and having only a small dip, might be worked by simple undercut quarries.

Lastly, the locality is the nearest to the Mahanadi, being only about six miles distant from that means of carriage. The chief difficulty in working this seam, indeed the only one that I know of, will be caused by water which it may possibly be found not very easy to dispose of, especially during the rains. This, of course, would only be felt while the works were carried on on a small scale; with extended operations suitable provision could no doubt be made, but the narrowness of the valley in which the seam is situated must always cause some trouble.

With this in view it would obviously be best to break ground first (provided, of course, that the seam is first proved to extend so far) at the watershed between Dibdorah and Jogidhipa; this would involve somewhat longer carriage, but would secure an outlet on either side for the ejected water. The water would almost entirely be from surface sources, as the red clays which occur with the upper sandstones would, I think, prevent excessive percolation from the water-bearing rocks of the highlands.

The sections given above of the other seams in this part of the field (Ebe valley area) do not indicate any coal of workable thickness. According to the assays and my rough examination in the field, No. 9 of the Durlipali is the best coal, but of it there is only one foot. No. 4 of the same section is two feet six inches thick, but the quality is very inferior. It must be remembered, however, that the whole of this seam, as well as that of most of the others, is not exposed. As regards carriage, the Durlipali seam is much less favourably situated than that at Dibdorah; the distance from Sambalpur as the crow flies is twenty-five miles. During the rains, however, the Ebe river, which is only six miles distant, might be used as a means of carriage. The Lukanpur seam, regarding which little is known at present, is situated in an enclosed valley difficult of access, the road to which from the Mahanadi would probably be from ten to twelve miles. The Dulunga seam is about sixteen miles from the Ebe. Of the large seams in the Baisunder I have spoken in my previous report; the coal from them might, perhaps, to a small extent, be brought down that river to the Ebe also during the rains.

Some of the seams in the Kelú valley may very possibly contain good coal, but they are difficult of access, being thirty-six miles, as the crow flies, from the Mahanadi. Carts, if they could get over the ground at all, would have to travel probably not less than sixty miles. To Sambalpur the distance by any possible route would not fall far short of 100 miles.

Still more unfavorably situated as regards roads are the seams in northern Hingir to the west. The Kurket river there, however, would afford a means of transport during the rains. I saw a large boat being built at Rabo on the Kurket, so that navigation is so far possible; indeed, the river bed, thence to its junction with the Mahanadi, contains no serious obstructions of any kind.

So little is yet known of the coal of the Talchir field, that it would be impossible at *present to institute a fair comparison* between the two. Unless the coal of our field is of* better quality it could not compete successfully in Cuttack owing to the much greater dis*tance it would have to travel.* At the same time the Mahanadi is closer to the eastern end of the Ráigarh and Hingir field than it is to any part of the Talchir field, and the Brah*mini, owing to* obstructions, is not much better as a means of transport than the Ebe or *Kurket would be.*

*The prospects of the ultimate development of this coal-field depend altogether on the future extension of a line of railway into that part of the country. If the project for con*necting Calcutta with Nagpúr, by a direct line, be ever carried out, this field will attain considerable importance, should the borings, which must first be made, prove the existence of abundant and good coal, and of their doing so, there is, I think, a fair prospect.

ASSAYS OF COALS†.

| | Moisture. | Carbon. | Volatile. | Ash. |
|---|---|---|---|---|
| Durlipali No. 4 of Sec. ... | 5·3 | 26·4 | 30·5 | 37·1 |
| Durlipali No. 9 of „ ... | 11·8 | 50·2 | 36·8 | 13· |
| Lakanpur ... ... | 9·2 | 33·4 | 34·4 | 32·2 |
| Dibdorah ... ... | 9·9 | 39·9 | 33·6 | 26·5 |
| Dulunga ... ... | 11· | 45·2 | 33·6 | 21·2 |
| Mograpali ... ... | 11·2 | 46·1 | 40· | 13·9 |

IRON.—Within the Barákar group there are, as has been indicated on a previous page, two and possibly three zones of ironstones. Assays have not been yet made, but some of the ores appear to be good. As to quantities, so far as superficial examination goes, I think at Kodaloi and some of the other localities on that horizon there is a large supply which could be easily worked. Of the abundance of ore in the hills at Rampur, east of the Ebe, I have already expressed my doubts, but on these points it is impossible, without some preliminary clearing of the ground, to speak with certainty.

The zone of ironstones which runs with the south-west boundary, at the top of the Barákars, seemed to be thin and poor.

In the upper sandstone series ironstones also occur, but are seldom used by the native *Lohars.* In several instances I found that the Lohars of villages which, owing to wood being abundant, were situated within the upper sandstone area, procured their ore from the Barákars some miles distant. Except towards the frontiers of the Hingir highlands, there are few *Lohars'* villages in that zemindari, but in no part of the country which I have visited are they so abundant as in Rampur. At many of the large villages there are furnaces, but the greater

* Selected coal from the Talchir field has been found to answer fairly well in small steamers on the Cuttack canals. Its cost, owing to expensive carriage, was, however, too high.

† By Mr. Tween.

number are worked by colonies of Lohars who form temporary villages where timber is abundant, passing to new localities when they have exhausted the supply in their vicinity. Although Sâl (*Shorea robusta*) is the wood most commonly used for making charcoal, I found the Bijasal (*Dipterocarpus marsupium*) seemed to be preferred by some. Bamboo, though abundant, never seems to be used. The wood is cut into logs about 3½ feet long, or rather more, and is burnt in holes which are about 4 feet square and 18 inches deep. Small branches are not used. The furnaces are somewhat smaller than the largest which are used in Bengal; they are furnished with a tray above, in which a quantity of mixed ore and charcoal is kept, which can be raked into the top of the furnace by the person working the bellows without other assistance. This, of course, is a great saving of labour as compared with the usual system which involves the presence of a second person to feed the furnace. Differing from the practice in Hazaribagh, the same individuals make the *giri* (bloom) and also work it up into iron for the market. The *giris* were much smaller than in Hazaribagh, in one case at Jodiboga not exceeding 6 or 7 seers, generally, perhaps, they are about 10 seers. So far as I could make out, the Mahajans get from 15 to 20 seers of iron for a rupee from the Lohars, but owing to the advance system and the transactions being chiefly in kind, this cannot be accurately ascertained.

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GEOLOGICAL SURVEY OFFICE,
*22nd October* 1875.

# RECORDS

OF THE

# GEOLOGICAL SURVEY

OF

# INDIA.

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# RECORDS

OF THE

# GEOLOGICAL SURVEY OF INDIA.

**Part 1.]** 1876. **[February.**

## Annual Report of the Geological Survey of India and of the Geological Museum, Calcutta, for the year 1875.

The close of another year brings with it the duty of reporting briefly the progress made during the past twelve months. As must almost necessarily be the case in such a department as the Geological Survey of India, the full number of the officers in the establishment has never actually been at work during the year; while even of those present and actively engaged, some have had their time almost fully occupied with subjects, not immediately forming a part of the Survey operations, although intimately connected with them.

In this way, Mr. W. T. Blanford was very fully occupied in the examination and description of the zoological collections collected in Yarkand by the late Dr. Stoliczka, and in arranging for publication the geological notes of the same trip. Mr. F. R. Mallet was absent on three months' leave, Mr. Hacket was absent on furlough till within a couple of months of the close of the year, and Dr. W. Waagen, who had only returned from Europe at the beginning of the season, was obliged again to leave India, and, to our great regret, and the very serious loss of the Survey, felt compelled to resign all hopes of returning.

Mr. Medlicott's labours in the earlier part of the year were confined to the coal-fields in the Satpura hills. Full notes of his researches have been already published, so that it is unnecessary to enter into any detail here. One important fact may be noticed. Towards the close of the season, Mr. Medlicott was fortunate enough to notice the occurrence of rocks, which he considers as undoubtedly representative of the upper part of the series accompanying the coal-bearing rocks elsewhere, at a point much further to the west than these had been known previously to occur. And he justly bases on the occurrence of these rocks a recommendation for further detailed search in the district, and suggests the propriety, seeing the vast importance of a supply of coal in that neighbourhood, of borings to test the occurrence of any such deposits. It would be essential that such borings, if attempted, should be carried to a very considerable depth, before any definite reply to the question of the existence of coal could be obtained. And in estimating the value of the chances, it will be essential to remember, as Mr. Medlicott himself remarks, that even if the coal deposits should be proved, it is impossible to make even a probable guess, as to the depth beneath the surface at which they are likely to lie, "2,000 is as likely as 500 feet."

Unless coal should be found in very considerable abundance, and most favorably placed as to dip, &c., I need scarcely say that mining it at a depth of 2,000 feet would be a matter of such difficulty, danger and cost in this country, that it certainly would not pay for many years to come, if ever, while even on general considerations, some of which have been partially explained before now, and have been confirmed by everything since noticed, I am not at all sanguine that any favorable deposits of coal will ever be found in the area indicated.

The geological facts noticed by Mr. Medlicott are of the highest interest as regards the structure of the valley of the Nerbada, and his suggestions must not be lost sight of in future investigations.

Up to date, no very definite results have been obtained by the borings now in progress at Toondnee and Khappa, but neither has any proof been obtained that the rods have reached beds below the coal-bearing rocks.

Mr. Medlicott, at the close of the season in the early part of the year, took advantage of an invitation to visit Khatmandu in Nepal, and a very interesting and suggestive notice of this visit is given by Mr. Medlicott in the Records of the Geological Survey of India for November last. It must always be a source of great regret that the movements of Europeans are so jealously watched in Nepal, that it is impossible to do more than pay a hurried visit to the localities immediately round the capital, or the places actually on or adjoining the road there and back. Mr. Medlicott saw, perhaps, everything that he could have seen, that is, that he would have been permitted to see, but this was barely sufficient to suggest a few possibilities as to the structure of the adjoining country, the correctness or incorrectness of which could not be established by further research. The continuity of the zone of newer rocks which fringes the Himalayan range to the north-west has been established, and the occurrence of the newer tertiary groups also proved.

At the commencement of the present working season, Mr. Medlicott, in conjunction with Mr. Theobald and Mr. Lydekker, commenced a revision of the tertiary rocks of the North-West and Punjab. The very important fact of a marked stratigraphical separation of two distinct groups of rocks in the Nahun country, which had previously been all considered as a continuous series of beds, was first noticed by Mr. Medlicott himself. The locality where this marked unconformity was noticed unfortunately did not yield any fossils from the lower group of the rocks, so that the very important question as to whether this marked separation of the rocks physically was accompanied by any distinction in their organic contents was still undecided. To determine this, it became necessary to trace the same two groups further to the north-west, and to collect the fossils from each group separately. In doing this, it became evident that the very marked unconformity noticed in the Markunda river did not continue to the north-west. And the separation of the groups must obviously be based on other considerations. Apparent distinctness in the fossils also on more careful examination disappeared, if not entirely, nearly so. It became, therefore, of the last importance that the separation of these groups should be more carefully investigated, and their relations one to the other established. And with this object in view, I requested Mr. Medlicott to go carefully over the entire ground again, giving him the aid of Mr. Theobald, who knew the fossil localities tolerably well, and had already brought together a very valuable collection from these rocks, and also the help of Mr. Lydekker, who had been all the previous part of the year engaged in a careful and earnest examination of the fossils, on which he had been able to throw much light. And I confidently hope that before the season closes, the boundaries of these tertiary groups may be demarcated and their relations established.

The vast importance, considered with reference to a study of the tertiary rocks of India, of a knowledge of the structure of Sind has long been patent. It has been more than once intended to take up the examination of that province. In 1869, arrangements were made for doing so, but other and more pressing demands caused this to be laid aside. Again in 1871, the same thing occurred, to our great regret. The sections in Sind were known to be unusually clear and well exposed; many of the rocks were richly fossiliferous, and while a very large number of species had been already collected and described, it had become evident that they had been erroneously referred all to the same series. It was also highly probable, if not certain, that we should in Sind find a connecting link between the tertiaries of Cutch and of the Sub-Himalayas. It was therefore with great satisfaction that we were able at last to depute Mr. Blanford, with the aid of Mr. Fedden, to take up Sind in 1874. Before the close of the working season of 1874-75, they had completed a fair sketch of the geology of the province, and have again this year resumed their labours there, Mr. Blanford also purposing to accomplish a traverse of the desert to Jessulmir and Jodhpur, and so probably back again by a different route to Sind. Mr. Fedden also has been able to bring together a very good collection of fossils, some of them very beautifully preserved.

During the summer, Mr. Blanford was, as already stated, chiefly occupied in working out the collections of Dr. Stoliczka from Yarkand preparatory to publication, but continued to superintend Mr. Fedden while he was carefully comparing the numerous collections brought from Sind, he himself taking up the Echinoderms, while Mr. Fedden confined his labours to the Mollusca. There was no time to investigate the Corals. A full sketch of the geological results is given in the present number of the Records of the Geological Survey of India, so that it is only necessary to mention briefly, here, that Mr. Blanford seems to have established the existence, in addition to the more recent and subrecent deposits, of rocks of pliocene, miocene, and eocene age, all of which had previously been roughly grouped into old tertiary. While in places there are still lower beds, the exact geological age of which is not fixed, but which are, in part at least, probably cretaceous.

Mr. Fedden has worked very earnestly and intelligently, and to Mr. Blanford's satisfaction, and by his careful study of the fossils collected last season, has acquired a knowledge of their forms and distribution, which will prove of very essential advantage to him during the present season in examining the continuation of the same rocks.

Mr. Willson has very steadily continued his work in the Bundelcund and Rewah country, and has mapped in several sheets of the new topographical survey, during the progress of which work, some important geological facts have been established.

Mr. Hacket only returned from leave of absence in Europe in time to take the field a little later in the season than usual in Rajpootana. Since then he has been actively engaged in Ulwar, and it is hoped that by the close of the working season, he will have completed a general geological sketch of that district.

During the entire season, Mr. Hughes was engaged in finishing up the geological maps of the Chanda country, with more especial view to the coal-fields of the Wardah valley. A report on these has since been completed, after most unlooked for delay, and is now gone to press. Mr. Hughes, during the present season, has taken up the continuation of same geological area to the south, and will, it is hoped, be able to join on his work to that of Mr. King, who is extending his examination from the south up the valley of the Godavery.

Mr. Ball completed the examination of the Raigarh and Hingir coal-field, on which he had been engaged during the previous season. Of this field, an interesting sketch is given by Mr. Ball, and published in the Records. During the present working season, Mr. Ball has been engaged in a revision of the Talchir coal-field, and in an examination of the Atgurh sandstones.

Dr. Feistmantel, who joined the Survey at the commencement of the year, has been most earnest and zealous in working out the fossil plants of the several groups of rocks in India, and has already accumulated much valuable matter. He has commenced the preparation of a history of the fossil flora of Kachh, which, taken in connection with the already published descriptions of some of the fossils from the associated beds, will prove of great interest and value. There is little doubt that the fuller and more careful investigation of the several floras from the successive groups of rocks will throw much light on the relation of the different members of what it has become a fashion to style the plant-bearing series.

In Madras Presidency, Mr. King completed the examination of the Rajahmundry country before leaving the field. I regret to have to report that exposure to the first burst of the monsoon before reaching station resulted in a very severe attack of inflammation of the eyes, which for some time assumed a very serious form. Fortunately this was conquered, and Mr. King's sight saved, although his recovery was tedious. Taking the field again at the commencement of the season he has visited the several fields near the lower valley of the Godavery, and closed up that part of the area, and has since proceeded northwards along the Godavery valley, with a view to joining Mr. Hughes, who has been carrying out the examination of the same valley proceeding southwards.

Mr. Foote succeeded in mapping in a good area of the country along the coast in the Nellore and Ongole country, and was fortunate also in finding some very beautifully preserved and interesting fossils of Rajmahal age. And in the present season he continues the same work northwards, with a view to join on to the Godavery and Rajahmundry areas. During the recess, Mr. Foote completed a valuable report on the Southern Mahratta Country, which is now in hands preparatory to going to press.

*Publications.*—Of the MEMOIRS of the GEOLOGICAL SURVEY OF INDIA, Vol. XI, Pt. 2, containing a detailed description of the salt-producing country in the Kohat district, Trans-Indus, was issued. The illustrations required for this part occupied some time, and the absence in Europe of the writer, Mr. Wynne, also involved some delay in reference in a few points.

Of the RECORDS of the Survey, the regular quarterly issue was punctually maintained, and the volume for the year will be found to contain several very valuable papers on the geological structure of various parts of India. "The paper on the Altum Artush, from a geological point of view," by the late Dr. F. Stoliczka, completed the series of short papers bearing on his trip to Yarkand, which he had left ready for publication. Among other descriptive papers, we have a note on the geology of Nepal by Mr. Medlicott, on the Khareean Hills in the Punjab by Mr. Wynne, a sketch of the geology of Scindia's territories by Mr. Medlicott, and a full sketch of the Shapur coal-fields, with notices on the explorations in progress in the Nerbada valley for coal: also an account of the Raigarh and Hingir coal-field by Mr. Ball, while the practical bearings of geological research are illustrated by Mr. W. Blanford's paper on the water-bearing strata of Surat, Mr. Hughes and Mr. Medlicott on fire bricks, Mr. Mallet on coal near Moflong, &c.

Of the PALÆONTOLOGIA INDICA, the publication of the Jurassic Cephalopoda from Kachh has been continued. The whole series is now completed and issued, although the difficulties caused by the preparation of such a large number of plates delayed this completion beyond the actual close of the past year. This series contains 60 plates, of which six are double, and 250 pages of letter press, with explanations of plates, &c., and is unquestionably one of the most valuable contributions to the fossil history of the Upper Jurassic Cephalopoda ever yet issued. This was all completed, though not printed off, when Dr. W. Waagen felt compelled to resign his connection with the Geological Survey of India. A great source of delay in the completion of the plates has arisen from the transfer of our offices to the New Museum, and the time, unavoidably lost, in moving and re-setting up the lithographic presses.

Good progress has also been made in the preparation of plates for the next issue of the Palæontologia Indica which will be devoted to the fossil flora of Kachh. It was hoped that we should have been able to continue the same detailed illustrations of the fossil mollusca in the other groups, as have now been published of the Cephalopoda. But the loss of our Palæontologist has for the present deprived us of the means of accomplishing this.

It will be seen that there have been issued during the year no less than 55 plates, equivalent, from double ones, to 61 of the regular quarto size, the annual number promised being only 48 (originally 24).

*Library.*—During the twelve months of 1875, 881 volumes or parts of volumes have been added to the Library of the Geological Survey. Of this number, 437 have been received from Societies and other Institutions in exchange for the publications of the Survey, or as donations, and 444 have been purchased. Quarterly lists of these additions have been regularly published as usual in the Records, and a nominal list of Societies and Institutions from which presentations or exchanges have been received is appended.

The removal of so large and valuable a series of books to the new offices of the Survey was a task of some risk and trouble, especially during the rains, but it was effected with but little injury. The greater space we have now at disposal has already admitted of a fuller and more detailed classificatory arrangement of the books than was previously possible. The completion of this arrangement will, however, necessarily occupy some time, and cannot be altogether satisfactorily accomplished until after the completion of the proposed gallery and another series of cases.

The Library continues to be a great resource to students, who can obtain access here to books, many of which do not exist in any other collection in Calcutta, or indeed in India.

*Museum.*—The removal of all the collections from the former offices of the Geological Survey to the new Museum was a task of no small trouble and labour, as well as risk. It could not have been expected that such a series could be moved without some injury to the more delicate fossils, and to the numerous casts of unique animals which our collection contains, nor was this danger diminished by the fact that the greater part of the removal was effected during the rains. It has consequently taken some time to restore all these things to their proper condition. With regard to the rearrangements of the full collections, inasmuch as no additional cases have as yet been provided for exhibition, we have been compelled for the present to content ourselves with merely grouping the collections and thus rendering them more easily accessible for the final arrangement when cases are available. Orders have been given for a considerable number already, and it is hoped that some will soon be ready.

The want of any out-offices has also compelled us to interfere seriously with the proper arrangement of the Museum by necessitating the storing away of tents, boxes with specimens, and other stores in the galleries of the Museum.

The collections are all in good order and preservation.

T. OLDHAM,

*Supdt., Geological Survey of India,*
*and Director of Geological Museum.*

CALCUTTA,
*February* 1876.

*List of Societies and other Institutions from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year* 1875.

BATAVIA.—Royal Society of Batavia.
BERLIN.—German Geological Society.
" Prussian Academy of Sciences.
" Gesellschaft für Erd Kunde.
BOMBAY.—Bombay Branch of Royal Asiatic Society.
BONN.—Naturhistorisches Vereins.
BOSTON.—Museum of Comparative Zoology.
" Boston Society of Natural History.
BRESLAU.—Silesian Society of Natural History.
BRISTOL.—*Naturalists' Society of—*
BRUSSELS.—Royal Academy of Sciences.
BUFFALO.—Buffalo Society of Natural Sciences.
CALCUTTA.—Asiatic Society of Bengal.
" Agricultural and Horticultural Society.
CAMBRIDGE, MASS., U. S., A.—United States Coast Survey.
CHRISTIANIA.—Royal University of Norway.
COPENHAGEN.—Royal Danish Academy.
DIJON.—Academy of Sciences, Dijon.
DRESDEN.—The Isis Society.
" The Leopoldino Carolino Academy of Naturalists.
" The Royal Museum.
DUBLIN.—The Royal Irish Academy.
" Royal Geological Society of Ireland.
EDINBURGH.—Geological Society of Edinburgh.
" —Royal Society of Edinburgh.
GENEVA.—Physical and Natural History Society of Geneva.
GLASGOW.—Philosophical Society of Glasgow.
" Geological Society of Glasgow.
GÖTTINGEN.—Royal Society of Science.
LAUSANNE.—Vandois Society of Natural Science.
LIEGE.—Geological Society of Belgium.
LIVERPOOL.—Literary and Philosophical Society.
" Geological Society.

LONDON.—East Indian Association.
„ Royal Geographical Society.
„ Royal Society.
„ Geological Society of London.
„ Anthropological Institute.
„ Royal Institution.
„ British Museum.
„ Linnæan Society.
MANCHESTER.—Geological Society.
MELBOURNE.—Geological Survey of Victoria.
„ Mining Department, Victoria.
„ Royal Society of Victoria.
MINNESOTA.—Academy of Science.
„ Geological Survey of Minnesota.
MOSCOW.—Imperial Society of Naturalists.
MÜNICH.—Bavarian Academy of Sciences.
NEUCHATEL.—Society of Natural Science at Neuchatel.
NEW HAVEN.—American Journal of Science.
NEW ZEALAND.—Colonial Museum and Laboratory.
„ Wellington. New Zealand Institute.
PARIS.—L'administration des Mines.
„ Geological Society of France.
PESTH.—Royal Hungarian Geological Institute.
PHILADELPHIA.—Franklin Institute.
PLYMOUTH.—Devonshire Association.
ROME.—Geological Commission of Italy.
ROORKEE.—Civil Engineering College.
SALEM, MASS., U. S., A.—American Association for the advancement of Science.
„ Essex Institute.
STOCKHOLM.—Bureau de la recherche Geologique du Suede.
ST. PETERSBURG.—Imperial Academy of Sciences.
SYDNEY.—Royal Society of New South Wales.
TORONTO.—Canadian Institute.
VIENNA.—*Imperial Academy of Sciences.*
„ K. K. Geologische Reichs-anstalt.
„ Zoologico-Botanical Society.
WASHINGTON.—Smithsonian Institute.
YOKOHAMA.—German Naturalists' Society.
ZÜRICH.—Swiss Palæontological Society.
„ Swiss Natural History Society.

Governments of India, Madras, North-Western Provinces, Punjab, and Bombay, Chief Commissioners of British Burmah, Central Provinces, Surveyor General of India, Superintendent of the Great Trigonometrical Survey of India, and the Superintendent of the Thomason College, Roorkee.

ON THE GEOLOGY OF SIND. BY WILLIAM T. BLANFORD, A.R.S.M., F.R.S., *Deputy Superintendent, Geological Survey of India.*

*Introduction.*—It has been for many years past an object of the last importance in making out the relations of the tertiary rocks of India to examine the geology of the province of Sind, and, but for the pressure of other work, the examination of that country would have been undertaken before. I was directed by the Superintendent of the Geological Survey on two previous occasions, in 1869 and 1871, to commence the survey of Sind, but other and more pressing work in each case interfered. During the working season 1874-75, a general examination of the province was made by my colleague, Mr. Fedden, and myself, the principal results of which are given in the following pages. The area of which a preliminary survey and sketch map were made exceeds 9,000 square miles, exclusive of the alluvial area. The survey is still in progress, and all recent observations tend to confirm the classification proposed.

A very large share of the work both in the field, and subsequently in the determination of the fossils, was done by Mr. Fedden, and the knowledge gained of the geology is quite as much due to his observations as to my own.

The importance of a thorough geological examination of Sind is due to two circumstances. *First*, it has long been known that there is in that province a fine series of tertiary rocks abounding in fossils. *Secondly*, the magnificent figures and descriptions of the Indian nummulitic fossils by Messrs. D'Archiac and Haime in their "Description des Animaux fossiles du groupe Nummulitique de l'Inde" published in 1853, probably the most important single contribution to Indian Geology ever issued in Europe, lose half their value from the circumstance that the exact position in the series of the beds from which the different fossils described were obtained was unknown. The majority of the fossils had been procured in Sind, but the exact localities were not recorded.

*Physical geography.*—The province of Sind consists geographically of the Indus valley and of the hill ranges to the west of the river, from the neighbourhood of Kashmor and Jacobabad, or the latitude of about 28° 30′, to the sea.

The whole province is generally divided into Upper and Lower Sind. Upper Sind consists of a broad alluvial plain extending for many miles on both banks of the river, but interrupted near Sakhar (Sukkur) and Rohri by a range of limestone hills, isolated in the alluvium and running nearly north and south. These hills are intersected close to their northern extremity by the river which runs at this spot from north-east to south-west, and they extend about fifty miles south of it. Beyond the flat alluvial tract east of the river is an extensive region of sandy desert. To the west of the river the alluvial plain extends to the mountains which form the frontier of the province, and which, under the name of the Khirthar range,* extend from the Bolan pass to considerably south of Sehwán. There is only one break in this range, that formed by the Gáj river, and the gorge of the stream is *quite impassable*; everywhere else the range rises to heights varying from about 3,000 to over 7,000 feet.

In Lower Sind the alluvial plain is almost confined to the left or east bank of the river, and between the Indus and the western frontier of the province the country is hilly. On

* In all old maps this and some other ranges were united under the name of the Hala range, but no such name is recognised in the province. By Vicary the term Hala-range was applied loosely to several distinct ranges, which, misled by the maps of the period, he evidently supposed to be portions of the same, and the name has thus come to be used commonly in works referring to the Geology of Sind. The result, as regards all attempts to identify the original fossil localities, is most confusing.

the east of the river there is an isolated low range of limestone hills near Hyderabad, and another near Tatta. The country west of the river consists partly of an undulating plain, partly of ranges of hills formed of limestone, and having a general north and south strike. The highest of these ridges are met with south and south-west of Sehwán: towards Kotri, Tatta and Karachi only low hills or undulating plains are found.

*Geological formations.*—Within the area of Sind no rocks have as yet been detected containing fossils of older date than Eocene, but the lowest rocks hitherto found in the province are unfossiliferous, or contain only a few vegetable remains which are not well preserved. From Dr. Cook's researches in Kelat, we know that mesozoic rocks with *Ammonites* are found in that direction, and at no great distance from our frontier; whilst from the Khirthar range close to the Gáj river, I saw lower beds cropping out from below the eocene limestone.

The result of the researches of the past year is that the following formations, in descending sequence, have been detected in Sind:—

| Name of group. | Approximate age. | Character of rocks. |
|---|---|---|
| Superficial beds, alluvium, &c. ... | Subrecent and recent ... | Blown sand. Alluvium of the Indus, both of the river plain and the delta. Slopes and deposits of gravel, often consolidated. |
| *Manchhar* or Sevalik ... | Pliocene .. ... | (*a*) Massive conglomerate on the edge of the alluvial plain; (*b*) clays, sandstones, and conglomerates, usually unfossiliferous, but sometimes containing bones. |
| *Gáj* or Supra-nummulitic ... | Miocene ... ... | Highly fossiliferous marine limestones, clays and sandstones, usually in thin beds; no nummulites. |
| 4. *Nari* or Upper Nummulitic ... | Lower miocene or upper eocene | (*a*) Sandstones, very massive and of great thickness, sometimes variegated; unfossiliferous, but interstratified towards the base with (*b*) yellow and brown limestones with *Nummulites garansensis*, *N. sublævigatus*, and *Orbitoides papyracea*. |
| 3. *Khirthar* or Lower Nummulitic | Eocene ... ... | (*a*) Massive, white and grey limestones with many species of *Nummulites*, *Alveolina*, &c.<br>(*b*) Highly fossiliferous yellow limestone with *Operculina canalifera*, &c. (local).<br>(*c*) Green clays of Rohri and Hyderabad. |
| 2. *Ranikot* or Infra-nummulitic | ? Lower eocene ... .. | Shales and sandstones, in part variegated and richly colored, thinly bedded, containing only vegetable remains. |
| 1. Volcanic ... ... | ? ... ... ... | Basalt. |

The new names proposed are all taken from well known localities in Sind. *Manchhar* is from the Manchhar Lake, on the southern and south-western banks of which the Sind representatives of the Sevaliks are well seen. *Gáj* is the name of a river which traverses the frontier range north-west of Sehwán, and exposes a superb section of the middle tertiary deposits. The name applied to the Upper Nummulitics is taken from the Nari Nai, a stream which drains the hills a little way south of the Gáj, and the upper course of which lies almost entirely amongst the formations named from it; whilst the Khirthar range, dividing the whole of Upper Sind from Kelat, gives its name to the great mass of Lower Nummulitic limestone, of which its higher ranges are entirely composed. The term proposed for the Infra-nummulitic group is taken from the stronghold of the Sind Amirs in the range north-west of Kotri. It appears to me better in every case to apply a local name than to use exclusively terms derived from European Geology, which may subsequently have to be abandoned, or to adopt names from other areas in India the rocks of which have not been distinctly correlated with those of Sind. There is, for instance, but little reason to doubt that the Manchhar group of Sind represents generally the Sevalik and Nahun beds of the Punjab; but still there is a question as to whether it corresponds only to one of those groups, or whether both are represented.*

It should not be forgotten that Messrs. D'Archiac and Haime had actually foretold† from their examination of the fossils the division of the Sind Nummulitics into two groups, an upper division with *Nummulites garansensis*, and a lower with *N. Ramondi, N Leymerici, N. granulosa, N. exponens, Alveolina ovoidea*, &c., and they also correctly indicated the existence of a third sub-division without Nummulites. But here the clue afforded by the Foraminifera failed them, for there are beds without nummulites at the extreme base of the series, and others at the top, and it was, of course, impossible for them to tell from which part of the series their fossils had been derived, except so far as the alliance to European forms guided them.

Subsequently it was shown by Professor Martin Duncan (Annals and Magazine, Natural History, Ser. 3rd, Volume XIII, p. 295), and by Mr. Jenkins (Quarterly Journal Geological Society, Lond., Vol. XX, p. 45), that many of the Sind fossils, and especially some corals which had not been described by Messrs. D'Archiac and Haime, were unmistakably of miocene age.

The rocks of Captain Vicary's classification,‡ to which allusion has so often been made in geological works, are the following, with their equivalents in the system now proposed:—

| Groups of Captain Vicary. | Groups now proposed. |
| --- | --- |
| 1. Conglomerate § ... | |
| 2. Clays and sandstone | |
| 3. Upper bone bed | Manchhar (Sevalik). |
| 4. Sandstone; fossils rare ... ... .. | |
| 5. Lower bone bed . ... ... . | |
| 6. Coarse, arenaceous, calcareous rock with *Cytherea exoleta*,‖ and *exarata, Spatangi*: no Nummulites ... . | Gaj (Miocene). |
| | Nari (Upper Nummulitic). |
| 8. Nummulitic limestone of the Hala Range | Khirthar, Lower Nummulitic. |
| 9. Black slates: thickness unknown ... | |

* During the past recess season, owing to a number of other demands upon my time, it has been impossible for me to investigate the relations of the Sind tertiary fauna as I could have wished, whilst, owing to the sad events which have deprived the Survey of its two Palæontologists successively, I have not had the advantage of aid from those better qualified than myself to determine palæontological questions. Under these circumstances, Mr. Fedden undertook the examination of the fossils collected, with such aid as I could give him; and although I believe that most of the identifications mentioned in the subsequent pages are trustworthy, I do not venture to hope that they are free from error. The *Echinodermata* and *Foraminifera* were examined chiefly by myself, the Mollusca by Mr. Fedden. Time did not permit of the corals being examined.

† Descr. An. Foss du Groupe Num. de l'Inde, p. 359.

‡ Quarterly Journal Geological Society, Volume III, p. 334.

§ This is the coarse conglomerate at the top of the series.

‖ Captain Vicary's fossil names have never been clearly identified. His *Spatangi* may have been *Breynia carinata, Echinolampas Jacquemontii, &c.*; his *Hypponices* I have been unable to trace. It is just possible they may have been *Lunulites*.

### Volcanic Rocks.

At the base of the section exposed at Ranikot, where the lowest beds found in the province are seen, and again in a similar position, as I learn from Mr. Fedden, north of Ranikot, basalt is seen. The exposure in each case occupies only a few square feet, and is very obscure. Nothing of importance with reference to this rock has been added during the past season to the observations made in 1863,* and it is still uncertain whether the basalt is intrusive or not, and, in the latter case, whether it belongs to the Deccan group of traps. Its relation to the overlying beds in the latter case is remarkably similar to what it is in Kachh.†

### 2. Ranikot Group or Infra-nummulitic.

These beds have already been described in the Memoirs.‡ They consist of sandstones, shales and clays, with gypsum, and are frequently remarkable for their bright and variegated colors. In some places the shales are carbonaceous, and irregular deposits of lignite occur in them, and they frequently contain pyrites and yield alum.

About 1,300 feet of these beds are exposed in Ranikot, between the base of the nummulitic limestone and the small hummock of basalt which forms the lowest of the rocks seen in the section.

The only organic remains observed in the beds themselves are vegetable, being dicotyledonous leaves, stems, &c. But north of Ranikot, Mr. Fedden found some bands of calcareous shale and limestone some distance below the base of the white Nummulitic (Khirthar) limestone and interstratified with sandstones and shales which may belong to the Ranikot group. These bands contain *Cardita Beaumonti*, *Nautilus Forbesi*, *N. Labechei*, and a few other fossils. Those above named have Cretaceous affinities. Further examination of the locality is desirable in order to ascertain the extent to which the two groups can be considered as interstratified. It should be noticed that neither *Cardita Beaumonti* nor the species of *Nautilus* have hitherto been obtained by Mr. Fedden or myself at any higher horizon than the extreme base of the Khirthar group.

The Ranikot group is but sparingly exposed in Sind. It is seen at Ranikot itself, and extends for some distance to the north, finally appearing on the outer scarp of the hills. It is also exposed within the range about four miles west of Ranikot, where it occupies a valley about five miles long by a mile broad, and there is a small tract composed of it around Lainyan south-east of Ranikot and north-west of Kotri. Here, however, the ground is greatly concealed by surface gravels, and much of the area to the westward is occupied by the grey sandstones of the Manchhar (Sevalik) group, which in places so closely resemble some of the sandstones of Ranikot that they cannot easily be distinguished.

### 3. Khirthar or Lower Nummulitic Group.

This is by far the most important and characteristic group of rocks in Sind, and all the higher hills of the province are composed of it. As usually developed, it consists of an immense thickness of massive grey and white limestone, abounding in Nummulites and other Foraminifera and unbroken by a single band of any other rock. Such is its character from the northern frontier of Sind to Kotri, but to the southward I am informed by Mr. Fedden that the group shows a tendency to break up into distinct beds, the typical hard limestone being interstratified with bands of softer limestones, sandstones, and shales, and in adjoining areas, in Kachh and Baluchistán, the massive white or grey limestone forms but a subordinate portion of the group.

* Mem. Geological Survey of India, Vol. VI, p. 5.
† Mem. Geological Survey of India, Vol. IX, p. 75.
‡ Mem. Geological Survey of India, Vol. VI, p. 4.

At the base of the Nummulitic limestone, fossiliferous beds occur in parts of the province. These beds it appears best for the present to associate with the Khirthar group, although they may ultimately prove worthy of distinction, or it may, as above suggested, prove necessary to class them with the Infra-nummulitic beds of Ranikot.

The most northern locality at which the basement beds of the Nummulitic group appear to be exposed in Sind is on the west side of the hills south of Rohri. Here beds of pale-green gypseous clays are seen, interstratified with a few bands of impure dark limestone and calcareous shale. These beds are fossiliferous, but the only species that has been recognised in them is *Natica longispira*, which appears to have a wide range in time, being found, according to D'Archiac, in the upper eocene beds with *Nummulites garansensis*. Species of *Lucina, Cardium, Leda, Pinna, Cerithium,* and *Rostellaria* also occur.

Similar green clay was observed by Mr. Fedden near Hyderabad, but no good section was found, nor were any fossils detected in it. In neither case was the base of the green clays seen, so that it is impossible to be certain whether they are not a band locally intercalated in the limestones. The latter appears most probable at Hyderabad.

At the base of the thick Nummulitic limestone in the Vero plain north-west of Kotri, and in similar beds on the same horizon near Jhirk (Jerruck) and Tatta, some very fossiliferous yellowish-brown limestone is found, in which the following fossils have been identified :—*

*Foraminifera.*

Operculina canalifera (very abundant).
O? Tattaensis, Carter.
Nummulites Leymeriei.
N. irregularis.

*Echinodermata.*

Cidaris Halaensis?
Porocidaris (spines).
Temnopleurus Valenciennesi.
Echinolampas? *sp.* (one very near E. subsimilis).
Eurhodia Morrisi.
Hemiaster digonus.

*Brachiopoda.*

Terebratula *sp.*

*Lamellibranchiata.*

Cardita Beaumonti.
Spondylus Rouaulti.

*Gasteropoda.*

Turritella angulata.
T. assimilis.
Nerita Schmedeliana.
Natica longispira.
Terebellum distortum.
Terebellum plicatum.
T. subbelemnitoideum.
Rostellaria angistoma.
R. Prestwichi.
R. fusoides.

*Cephalopoda.*

Nautilus subfleuriausianus.
N. Deluci.
N. Labechei.
N. Forbesi.

* In this and other lists D'Archiac and Haime's names are used. Their genera often differ from those employed by more modern writers, and their specific determinations may, in many cases, require revision; some of their species, for instance, being probably identical with well known living forms.

The Mollusca are only mentioned, as a rule, when they have been determined specifically. All the Echinodermata found are included in the lists, whether they have been identified specifically or not.

The massive Nummulitic limestone itself abounds in fossils, especially *Foraminifera*, but owing to the nature of the rocks and their mode of weathering, their organic contents usually only appear in section on the weathered surface. Corals, *Echinodermata* and *Mollusca* abound, but the latter, as a rule, weather out as casts. The following are some of the most characteristic fossils identified :—

*Foraminifera.*

Orbitolites sp.
Orbitoides dispansus.
Patellina Cooki.
Alveolina ovoidea and A. spheroidea.
Nummulites obtusa, Ramondi, Biaritzensis, Beaumonti, Vicaryi, exponens, granulosa, spira, and Leymeriei.

*Echinodermata.*

Echinolampas discoideus.
E. Sindensis.
Eurhodia Calderi.
Conoclypeus pulvinatus?
Amblypygus sp.
Fibularia sp.
Eupatagus avellana.
Schizaster sp.
Brissopsis Sowerbyi?
B. scutiformis.
B. sp.

*Lamellibranchiata.*

Ostrea vesicularis (O. globosa, Sow.)
Pholadomya halaensis.
Vulsella legumen.

*Gasteropoda.*

Nerita Schmedeliana (very abundant).
Ovulum Murchisoni and other species.

*Crustacea.*

Arges Murchisoni (Galenopsis Murchisoni).
Ranina sp.

Amongst the above the most common and characteristic forms are *Orbitoides (dispansus*, Sow.), *Nummulites* of various species, *Alveolina*, and *Nerita Schmedeliana*. Of the age of this group it is unnecessary to say anything, as it is, of course, the same as that of the Nummulitic limestone of Southern Europe, *viz.*, typically eocene.

The thickness of the Khirthar group has not been determined, but, where fully developed in the Khirthar range, it cannot be less than 3,000 feet, and it may be twice as much. To the south, however, the thickness must diminish greatly, and near Jhirk and Tatta it, probably, does not exceed a few hundred feet.

The Nummulitic limestone forms the whole higher portion of the Khirthar range from the northern frontier of Sind to the termination of the range within the province about fifty miles south-by-west of Sehwán. It also composes the range which under various names, Lakki, Eri, Daphro, &c., runs south from Sehwán to beyond Bula Khán's Thana, and the several ridges to the westward near the Habb, the southernmost of which terminates at Cape Monze. It, moreover, occupies a considerable tract of country near Kotri and Jhirk (Jerruck), and forms the isolated hills of Sakhar (Sukkur), Rohri, Hyderabad, and Tatta.

### 4. Nari or Upper Nummulitic Group.

The upper sub-division of the nummulitics of Sind is, where best developed, very nearly, if not quite, equal in thickness to the lower, but its composition is very different. At the base it contains a variable thickness of brown and yellow limestone abounding in *Nummulites garansensis*, *N. sublævigata*, and *Orbitoides Fortisi* (= *O. papyracea*, Boubée), interstratified with sandstone and shale. These beds are in places five hundred feet thick, but usually much less. All the upper portion of the group consists of massive sandstone beds, which are generally quite unfossiliferous, but occasionally contain bands of clay and shale with fragmentary plant remains. Towards the base of the sandstone, beds of limestone with the characteristic *Nummulites* are occasionally interstratified, sometimes five hundred feet, or even more, above the principal limestone beds at the base of the group; thus clearly showing that the limestones with *Nummulites garansensis*, &c., belong to the same sub-division of the tertiary series as the sandstones.

In many places, especially towards the base, very ferruginous bands are interstratified with the sandstones; and south of Sehwán, on the west side of the Bhagotoro range, where the thickness of the whole group is much less than in the Khirthar range, the upper portion consists of ironstone, ferruginous sandstones, and brightly coloured clays, purple, brown, and white. On the Khirthar range, however, almost the whole group, except at the base, is composed of massive beds of brown sandstone. Throughout the area examined, the upper nummulitics rest conformably upon the lower, but there is a complete break in mineral character, and the fossils are different, the two characteristic species of Nummulite, for instance, being distinct from any hitherto found in the Khirthar group.

The whole thickness of the Nari group on the Khirthar range can scarcely be less than five thousand feet.

In some places the limestones at the base of the Nari group contain a large number of Mollusca and Echinodermata. The following have been identified; a large proportion are from Bhagotoro, south of Sehwán:—

*Foraminifera.*

Nummulites garansensis.
N. sublævigata.
Orbitoides Fortisi.*

*Echinodermata.*

Cidaris Verneuili.
Cœlopleurus Forbesi.
Echinanthus profundus?
Echinolampas, sp. nov.
Eupatagus rostratus.
Schizaster Beloutchistanensis.
S. Newboldi?

*Lamellibranchiata.*

Corbula harpa.
Venus granosa.
Cardium triforme.
Pecten Labadyei.
Ostrea flabellula.

Natica patula.
N. sigaretina.
N. decipiens.
Siliquaria Granti.
Solarium affine, 2 vars.
Trochus cumulans.
Phasianella Oweni.
Turritella Deshayesi.
T. angulata, var.
T. Renevieri.
Triton Davidsoni.
Voluta jugosa.
V. dentata.
Cypræa nasuta and other species.
Terebellum obtusum.

The most common forms being the *Foraminifera* and *Pecten Labadyei.*

* *O. papyracea* (Boubée): see Geological Magazine, November 1875, p. 535. As before remarked, for convenience sake, D'Archiac and Haime's specific names are preserved throughout this paper. I believe this rhizopod to be correctly identified, but at the same time it appears to me to be the species identified by Dr. Carter with *O. Mantelli.*—Journal, Bombay Branch Royal Asiatic Society, vi, pp. 79, 82, &c., &c.

Although the relations of the fossils named above appear, on the whole, to be Eocene rather than Miocene, there being a predominance of species such as *Natica patula*, *N. sigaretina*, *Ostrea flabellula*, *Voluta jugosa*, &c., found, or represented by closely allied forms, in Eocene beds in Europe, there is a considerable admixture of species with Miocene affinities, such as *Siliquaria Granti*, *Solarium affine*, and *Echinanthus* (*Clypeaster*). Of the two characteristic species of Nummulites also, one, *N. sublævigata*, is peculiar, being unknown out of India, whilst the other, *N. garansensis*, is met with in the lower Miocene beds of France.*

It should not be forgotten that the fossiliferous beds are at the base of the Nari group, and if, as appears probable, these are high Eocene, the upper portion of the division may, very possibly, be of Miocene age.

The rocks of the Nari group extend nearly throughout the Khirthar range, forming a belt of lower hills along the western base of the main ridge. This belt varies greatly in breadth, but is rarely less than from two to three miles across, except in the extreme north, close to the frontier, where these beds are cut out apparently by a fault, or squeezed into a narrow belt, a few feet in width, and in the extreme south, where they appear, in places, to have been removed by denudation. On the Gáj river, the tract of country occupied by upper Nummulitic rocks is about three and a half miles wide; on the Nari Nai, from which its name is taken, it expands greatly and is six miles broad. The same rocks occupy the broad valley of the Angai stream south of the Nari, and, sweeping round the northern termination of the Bhit range, form the greater portion of the valley to the eastward Their area in this direction has, however, yet to be ascertained. They are largely developed in the broad valley of Chorlo and Malirri running south from the Manchhar Lake, and they are met with again about Tatta, but they do not appear to be found east of the Laki Kara and Eri range between Sehwán and Kotri. They, however, occupy a large tract of country near Júngsháhi, and are represented in many parts of Kohístán. Their area towards Karachi remains to be determined.

### 5. Gáj or Supra-nummulitic Group.

Above the sandstones of the Upper Nummulitics there is found a group of highly fossiliferous limestones, sandstones, and shales, distinguished by a very different fauna, from which *Nummulites* are entirely absent. This group is easily recognised by being composed of several thin bands of hard limestone, usually of a brown colour, but occasionally white, with sandstones and shales interstratified, in bands of small thickness. The limestone weathers into ridges which may frequently be traced for miles amongst the outer hills of the Khirthar range.

The most characteristic bands of limestone are about the middle of the formation. They contain *Echinodermata* (especially *Breynia carinata*) in considerable quantities, and they frequently abound in corals. The *Echinodermata* appear, as a rule, to be confined to one bed, but further examination is necessary: all that can be positively asserted is, that a band of limestone, abounding in fossil sea-urchins, occurs throughout a large area at about the same horizon. Towards the base of the group shales and sandstones prevail, but the latter may, as a rule, be easily distinguished from similar rocks in the underlying Nari group by being comparatively thin, each bed rarely exceeding eight or ten feet in thickness, and by their being interstratified with shales or limestone, often fossiliferous. The upper portion of the Gáj group consists usually of calcareous sandstone and hard marls, with shales and clay, and the uppermost beds frequently abound in *Turritella angulata* and other allied species of the same genus. In some localities, as on the Maki Nai, and again

* D'Arch. and Haime, An. Foss. Num. de l'Inde, p. 101.

on the Khenji Nai, the highest beds of the group are clays with gypsum, containing, besides *Turritella angulata*, the following fossils:—

| | |
|---|---|
| Corbula trigonalis. | Tellina subdonacialis. |
| Lucina (Diplodonta) incerta. | Arca Larkanensis. |

These beds may, very probably, be estuarine, for *Arca granosa*, the living Indian representative of *Arca Larkanensis*, is one of the most typical of estuarine mollusks, and the *Tellina*, *Corbula*, and *Diplodonta** all have allies living in estuaries. These supposed estuarine beds are quite conformable to the overlying Manchhar (Sevalik) group and appear to pass into it.

The Gáj group, where best developed, as on the Gáj river, is at least one thousand feet thick. As a rule, throughout the Khirthar range, it is conformable to the Upper Nummulitics, but west of the Manchhar Lake, near Tandra Rahim Khán, it rests unconformably upon all the older beds, for its outcrop extends in a nearly straight line across the Angai valley, which is formed by a synclinal of the Nari or Upper Nummulitic group. Further south, in the country south-west of Bula Khán's Thana, the Gáj beds are nearly horizontal over a large area, whilst the nummulitic beds, both Khirthar and Nari, where they rise to the eastward from beneath the newer formation, exhibit much greater disturbance. In one spot near Bula Khán's Thana Gáj beds were found resting directly on Lower Nummulitics.

The following is a list of the principal fossils identified from the Gáj group. Foraminifera are not very common, and hitherto in Sind, as has been already mentioned, no species of *Nummulites* has been observed in these rocks:—

*Foraminifera.*

Operculina canalifera?

*Echinodermata.*

| | |
|---|---|
| Cœlopleurus Forbesi, var. | Echinolampas Jacquemonti. |
| C. (sp. nov.?) | E. spheroidalis? |
| Echinus Stracheyi? | Breynia carinata. |
| Echinanthus profundus. | Brissus (Meoma) sp. |
| E. halaensis? var. | Maretia sp. (undistinguishable from the recent *M. planulata*). |
| E. sp. | Schizaster sp. |
| Echinodiscus sp. (near the recent *E. auritus*, but with closed lunules). | |

*Lamellibranchiata.*

| | |
|---|---|
| (? Kuphus) rectus† (Serpula recta, Sow). | Arca Larkhanaensis. |
| Corbula trigonalis. | A. Peethensis. |
| Tellina (Macoma) subdonacialis. | A. Kurrachiensis. |
| Lucina (Diplodonta) incerta. | Pectunculus pecten. |
| Astarte hyderabadensis. | Pecten corneus. |
| Venus granosa. | P. Bouei. |
| V. cancellata. | P. Favrei. |
| V. (Tapes) subvirgata. | Spondylus Tallavignesi. |
| V. (Dosinia) pseudoargus (= *D. exasperata*, Chemnitz, recent). | Ostrea multicostata. |
| | O. hyotis (recent). |
| Cardium anomale. | O. denticulata (ditto). |

* Mr. G. Nevill has done me the favour of comparing the *Diplodonta* and some other species, and I learn from him that a living species common in the Indian seas, which neither of us can distinguish from the fossil *Diplodonta*, is unnamed. I am not acquainted with the precise habitat of the living form, but either the same or a closely allied species occurs with estuarine Mollusca at Bombay. The *Tellina* belongs to the subgenus *Macoma*, and is very close to *T.* (*Macoma*) *myæformis*, Sow., a common recent estuarine species.

† A form undistinguishable from this is found also in the Khirthar group. In both cases the tube is certainly that of a mollusc, not of an annelid.

*Gasteropoda.*

Turritella angulata. Buccinum Cautleyi.
Buccinum Vicaryi.

*Crustacea.*

Balanus sublævis. Palæocarpilius rugifer.*

The most characteristic fossils of the formation are *Breynia carinata* and *Ostrea multicostata*. Species of *Clypeaster* (*Echinanthus* apud D'Archiac and Haime), *Echinolampas Jacquemonti*, *Kuphus* (*?*) *rectus*, *Venus granosa*, *Arca Larkhanaensis*, *A. Peethensis*, *A. Kurrachiensis*, *Pecten Favrei*, *Turritella angulata*, and *Balanus sublævis* are also common.

That the above fauna is later than Eocene is self evident, the genera of Echinodermata alone being amply sufficient to prove the later tertiary age of the rocks. I feel some doubt as to whether the group is as old as the Miocene of Europe. It must be borne in mind that one important characteristic of the European Miocene is the presence of genera now confined to tropical or subtropical seas, and consequently a similar fauna in subtropical Indian rocks may indicate a later geological age. The definite test of the age of Indian later tertiary rocks must be the same as that applied by Lyell and others in Europe—the comparison of the fossils with the fauna now living in neighbouring seas—and until this can be made, only a provisional age should, I think, be assigned to the beds. Whilst, therefore, the Gáj group may for the present be called Miocene, as forming the middle tertiary group of Sind, I think it possible that it may ultimately prove Pliocene, and that the Nari beds are, in part at least, the equivalents of the European Miocene. Bearing in mind that the fossiliferous beds at the base of the Nari group have unmistakable miocene affinities, it is impossible to consider the Gáj beds older than Upper Miocene.

The Gáj group is found throughout the Khirthar range, and usually forms the first well marked ridge west of the lower hills of soft Sevalik (or Manchhar) sandstones. South of the Nari Nai, this belt of middle tertiary beds turns to the south-east, and finally more to the eastward, and it forms a range of hills of small elevation about four miles south-west of the Manchhar Lake. To the south-west of the lake, the group appears to be entirely wanting, and the Sevaliks rest, apparently conformably, upon the Upper Nummulitics (Nari). The Gáj beds are also absent east of the range running south from Sehwán.† They, however, appear in places in the valleys to the west of that range, near Bula Khán's Thana; and south-west of that place and of Tong they occupy a very large tract of country, hitherto imperfectly examined, extending south-east towards Júngshāhi, and west towards the Habb river, along which they stretch to the neighbourhood of Karachi. Their relations with the overlying rocks in this country require further examination.

### 6. Manchhar or Sevalik Group.

The highest group of the Sind tertiary series has hitherto received but little attention. It is unfossiliferous as a general rule, and there can be but little doubt of its representing formations better exhibited and more fossiliferous in the Sub-Himalayan region, and already widely explored. It is far from impossible that further study of the Sind beds may show that they are separable into two or more sub-groups. In one instance at least there was observed evidence of probable unconformity between different portions of them.

* Stoliczka, Pal. Indica.

† A bed only two or three feet thick has just been found representing them near Vero. It rests on Khirthar limestone, and contains *Ostrea multicostata, Pecten Favrei, &c.*

The Sevalik beds in Sind consist of clays, sandstones, and conglomerates. The clays are usually buff or red in colour, the sandstones reddish-brown or grey. One very characteristic bed is a rather fine greenish-grey sandstone composed of fragments of quartz, felspar, and hornblend. This sandstone is often quarried for platters used to bake bread upon. In the reddish-brown sandstone the hornblend is absent.

The conglomerates vary much in character. As a general rule, and especially towards the base of the group, they contain rolled fragments of argillaceous sandstone and clay, closely resembling the associated beds in the same group. As a rule, too, except in the upper conglomerate at the top of the group, pebbles of the older tertiary formations are wanting; but in a few instances they have been found. This is the case in one bed on the Khenji Nai, and conglomeratic bands containing Nummulitic limestone and Gáj (Miocene) limestones are seen on the road between Shah Hassan on the Manchhar Lake and Pir Gáji.

On the top of the Manchhar or Sevalik and on the edge of the alluvium there is found, in most parts of the Khirthar range, a very thick bed of coarse conglomerate composed of large pebbles of nummulitic limestone and other rocks, amongst which fragments of a quartzite are abundant. This conglomerate bed in places, as at the outlet of the Gáj, cannot be less than two or three hundred feet thick. It is disturbed and inclined like the Manchhar beds beneath it, and it appears conformable to them. It has, however, an appearance of passing upwards into the gravels of the slope outside the range, but such appearances are sometimes fallacious. At the same time it is far from improbable that the conformity of this conglomerate to the Manchhar beds may be only apparent.

The thickness of the Manchhar group in Sind has not been ascertained with any certainty, but it can scarcely be less in places than five thousand feet.

Except near Karachi, where some oysters were found by Mr. Fedden in beds apparently belonging to this group,* no marine fossils have hitherto been obtained in it, and the principal recognizable remains of vertebrata hitherto collected by the Survey are some bones and teeth of Rhinoceros and Crocodile. Captain Vicary and some other explorers appear, however, to have found bones in larger numbers.

From the circumstance that the Manchhar group rests unconformably on the Gáj beds, which are at the oldest Upper Miocene, it is manifest that the Manchhar group itself cannot be older than Pliocene. This result is extremely important, if, as appears almost certain, the Manchhar beds of Sind are the equivalents, in part or wholly, of the Sevalik and Nahun beds of the Punjab, since the latter have generally been referred by all writers to a Miocene epoch.† The Makrán group, the possible equivalent of the Manchhar in Baluchistán, is newer Pliocene or Pleistocene.

It appears to me that the Sind beds cannot be of marine origin. With one or two local exceptions, they are entirely destitute of mollusca or other forms of marine animal life, whilst similar beds in the Gáj group just below are full of fossils. The coarse conglomerate at the top of the group is chiefly composed of pebbles which appear to have been rolled in streams, their form being too oblate for them to have been formed on a sea beach. I am strongly disposed to suspect that the Manchhar group, despite its enormous thickness, is

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* Within the last few days, some more oysters have been found, also by Mr. Fedden, at Vero, west of Kotri. They are accompanied by two kinds of *Balanus*.

† I have, for a long time past, doubted whether the Sevalik rocks were correctly referred to so early a date as the Miocene, and I expressed my doubts, mainly founded on the great proportion of remains of ruminants to those of other orders, to Dr. Falconer himself as long ago as 1862.

of subaerial origin, the clays having, probably, been formed in an alluvial plain, and the conglomerates and sandstones deposited by streams and the wash of rain from hills.

The Manchhar group is unconformable to the Gáj group. This is proved by the occurrence of fragments of the Gáj limestones in places in the Manchhar conglomerates, and also by the newer group in places near Sehwán and Kotri overlapping the older and resting unconformably upon the upper or lower Nummulitic beds. But, as a rule, throughout the Khirthar range, the Manchhar beds rest conformably on those of the Gáj group.

The Sind Sevaliks form a belt of low hills on the flanks of the Khirthar range as much as fourteen miles in breadth near Ghaibi Dero, west of Larkana, but usually not more than four or five miles wide. South and west of the Manchhar Lake the same rocks occupy a considerable tract of undulating country. They are found on the west side of the Laki hills, south-west of the Manchhar, and they cover much of the ground between the Indus and the continuation of the same range to the southward. They are also met with locally about Bula Khán's Thana and in some of the other valleys of Kohístán. Their extent near the coast is obscure, for they appear to change in character in this direction, and they may be represented by the Makrán group:* but this point has not been determined as yet.

The Manchhar beds were evidently deposited before the elevation of the Khirthar range. since they are tilted up with the beds of which the higher hills are formed. They thus mark the close of the tertiary period in Sind, and a break exists between them and the undisturbed formations of more recent date.

## 7. Recent and Sub-Recent Deposits.

Although these cover the greater portion of Sind, they possess but little geological importance by themselves. They are merely local forms of wide spread formations, and, from their simplicity, demand but brief notice.

The alluvium of the Indus plain is rather sandy, perhaps in consequence of the great extent to which sand is carried over the country by wind. Otherwise the alluvium presents no peculiarities, or at least none have been observed.

Along the base of the Khirthar and other ranges are slopes of gravels similar to those found in Persia and the dry regions of Central Asia, but on a much smaller scale. These deposits are evidently due to the wash of rain and small streams, and similar slopes occur in all countries, but they are peculiarly conspicuous in the desert regions, in consequence of the absence of vegetation.

Large accumulations of gravel and sand are found in many of the valleys between the ranges in Lower Sind and amongst the lower hills of the Khirthar. These gravels are often cemented into a conglomerate by carbonate of lime.

Blown sand is frequently found in parts of the Indus plain covering the surface and forming low hillocks. To the east of the Indus it covers a large tract of desert country, separating Sind from Rajputana.

*On the correlation of the Sind tertiaries with those in neighbouring countries.*—The importance of a knowledge of the rocks of Sind, for the purpose of affording a clue to the tertiary geology of other parts of India, has already been noticed. Much additional study of the fossils is necessary before anything like accurate correlation is practicable, and it is possible that the distribution of organic remains in the tertiary rocks of other parts of India may differ slightly from that found in Sind.

* Records, Geological Survey, India, 187 vol. v, p. 41.

The tertiaries of Kachh, south-west of Sind, were described by Captain Grant in 1837, and have since been mapped and classified by Messrs. Wynne and Fedden (Mem. Geol. Surv. India, Vol. IX). The following groups were distinguished by the latter. I place against each its probable equivalent in Sind:—

| *Kachh.* | *Sind.* |
|---|---|
| F. Upper Tertiary. | Manchhar or Sevalik. |
| E. Argillaceous group. | Gáj or Supra-Nummulitic. |
| D. Arenaceous group. | Nari or Upper Nummulitic. |
| C. Nummulitic group. | Khirthar or Lower Nummulitic. |
| B. Gypseous shales.<br>A. Sub-Nummulitic. | } ? Ranikot or Infra-Nummulitic. |

At the same time it is only just to state that these identifications are chiefly based upon fossil evidence contained in the detailed descriptions,* and that this evidence does not always coincide with the distribution of organic remains found in Sind. For instance, Nummulites are said to have been found in the argillaceous group of Kachh,† whilst none have hitherto been met with in the corresponding Sind formation. Mr. Fedden tells me that it is probable that the mapping of portions of the Kachh tertiaries, which are frequently very ill-exposed, may require alteration. Some of the identifications of fossils, too, were made with imperfect means of comparison. Unfortunately it is not specified in the Memoir which of the identifications are by Dr. Stoliczka, who compared most of the forms enumerated in the detailed descriptions.

Of Kathiawad we only know as yet that a tertiary series is found, near the base of which Nummulitic limestone occurs. Above this Mr. Theobald, in his manuscript report, enumerates in ascending order (α) *Venus granosa* beds, which are probably, in part at least, the representatives of the Gáj group of Sind; (β) Perim beds, approximately of Sevalik age, and, therefore, corresponding to the Manchhar group of Sind, and (γ) Milliolite beds, which are, possibly, the equivalents of part of the Mákrán group, and are not, so far as we know, represented by marine beds in Sind at all.

In Eastern Gujrat,‡ in the districts of Surat and Broach, the tertiary formations above the volcanic series of the Deccan traps are very ill-exposed. Near their base limestone is found with numerous fossils, several of which are characteristic of the Sind Khirthar group (Eocene), whilst higher in the series sandstones, clays, and gravels with *Balanus* and other fossils occur. These may, possibly, represent the Gáj group of Sind.

Turning northwards from Sind, the first place (with the exception of the hills north of the modern Jacobabad, briefly described by Captain Vicary) of which we have any definite information is the portion of the Suliman range, recently examined by Mr. Ball,§ west of Dera Ghazi Khan. Mr. Ball describes beds, which he considers of Sevalik age, resting upon sandstones with clays; the latter beds are, probably, the representatives of the Sind Manchhar group, and Mr. Ball's Sevaliks may correspond to the massive conglomerate found in Sind at the top of the tertiary series.

Of course, considering that Mr. Ball made only a flying visit to the hills at the most unfavourable season of the year, he may have easily overlooked some groups, and representatives of the Gáj and Nari beds of Sind could scarcely have been detected without a careful survey. Still the absence of the massive sandstones of the former group is important.

* l. c. pp. 231, 289.

† pp. 253, 280.

‡ Memoirs Geological Survey of India, VI, pp. 61-65, 208, &c.

§ Records Geological Survey of India, VII, p. 145.

But the lower portion of Mr. Ball's section corresponds well with what is known of Sind. He found Nummulitic limestone, evidently of Khirthar age, resting upon a great group of alum shales and sandstone with coal, apparently representing the Ranikot beds of Sind.

So little has as yet been ascertained definitely about the Punjab tertiary rocks, that it is best to defer all attempts at identifying them until more is known of their organic remains. With the Sub-Himalayan rocks described by Mr. Medlicott,* the following are possible identifications, but the absence of marine fossils in the two upper sub-divisions of the Sirmúr group renders comparison difficult:—

| *Sub-Himalaya near Ganges.* | | *Sind.* |
|---|---|---|
| Sevalik | ... ... ... ... ... | Manchhar. |
| Náhan | ... ... ... ... ... | Manchhar. |
| Sirmúr ... | Kasaoli ... ... ... ... | ? |
| Sirmúr ... | Dagshai ... ... ... ... | ? |
| Sirmúr ... | Sabathú ... ... ... ... | Khirthar. |

The most striking point is that so far as the examination has hitherto proceeded, no marine representative of the Gáj Miocene group has been found north of Sind, unless the occurrence of a single valve of *Lucina (Diplodonta) incerta* in the Salt range† be evidence of its existence. Mr. Medlicott notes the existence of *Ostrea multicostata* in the Sabathú group,‡ but it is far from clear that this species, although it is so common in the Gáj group as to be a characteristic fossil, is confined to that horizon even in India. In Europe it is an Eocene form. Whether the Kasaoli or Dagshai beds represent the Nari group of Sind remains to be determined.

Lastly, west of Sind, in Mákrán, there is found a thick group of marine beds of very late age, certainly not older than Pliocene. This group, which is greatly developed near the coast, I have proposed to call the Mákrán group.§ It rests with apparent local conformity on an immense thickness of sandstones and shales, in which occasionally beds of Nummulitic limestone occur. All this lower portion of the series, in the only country in which I was able to examine it, is greatly disturbed and altered, all the beds, as a rule, being vertical or nearly so, and it was impossible to classify the rocks below the Mákrán group.

This Mákrán group is certainly unrepresented in Sind by any marine beds hitherto examined: (it must be borne in mind that the neighbourhood of the coast requires further attention:) most of the included fossils are recent species, and not a single characteristic Gáj (Miocene) form has been detected in Mákrán except *Arca (Parallelopipedum) tortuosa*, which may prove undistinguishable from *Arca Kurrachiensis*.

The natural suggestion arises that the Mákrán group may represent the Manchhar formation of Sind: but this remains to be proved. The one formation is exclusively marine, the other freshwater, and until the intervening area has been examined, it would be premature to speculate upon the relations of the two to each other.

*P.S.—December 23rd*, 1875.—Since the above sketch of Sind geology was written, the rocks beneath the Khirthar group have received further examination, and the result shows that the fossiliferous brown limestones of Tatta, Jhirk, and the country north-west of Kotri must be classed with the Ranikot or Infra-Nummulitic, and not with the Khirthar

* Memoirs, Geological Survey of India, III, pt. 2, pp. 17, &c.
† D'Arch. and Haime, An. Foss. Num. de l'Inde, p. 240.
‡ l. c. p. 100.
§ Records, Geological Survey of India, 1872, Vol. V, . 41.

group. A list of some of the principal fossils obtained from these brown limestones was given above (p. 12). It has also been ascertained that the Khirthar group rests unconformably, in places at least, on the Ranikot group, the unconformity being clearly seen at Hothian pass, ten miles south of Ranikot. This unconformity explains the absence of the fossiliferous brown limestones, which are the highest known members of the group, at Ranikot itself.

Basalt, precisely similar to that seen at the base of the Ranikot section, has been traced in several places along the range north of Ranikot, and proves to be a lava flow 30 to 40 feet in thickness, distinctly interstratified with the sedimentary beds of the Ranikot group. A second flow has been found at a lower horizon. The bed containing *Cardita Beaumonti* is inferior to the upper basaltic stratum.

Beneath the shales and sandstones exposed at Ranikot, and below the *Cardita Beaumonti* bed, there is a great thickness of brown, reddish, and white sandstones and conglomerates and some dark-coloured gritty limestone, and at the base of these beds white limestones appear, in which no nummulites have been detected and which may prove cretaceous. Unfortunately, the south of Sehwán and Lakki Range, in which the sections are exposed, is difficult of access. It is hoped that a fuller account of these interesting beds may be given hereafter.

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# RECORDS

OF THE

# GEOLOGICAL SURVEY OF INDIA.

**Part 2.]** 1876. **[May.**

## The Retirement of Dr. Oldham.

This number of our Records would be sadly wanting without a word of grateful farewell to the man who has conducted the labours of the Geological Survey of India from their beginning until now. When Mr. Oldham came to India in 1851, the Geological Survey cannot be said to have existed. Some coal-viewers and improvised geologists had made occasional reports to Government, but there was nothing that could be called an institution, either as to staff or abiding-place. Professor Oldham conferred at once upon his post the influence of a well-known name, and the experience he had for years acquired as Director of the Geological Survey of Ireland. With those guarantees, by personal address and energy, he quickly acquired the confidence of Government, and by its liberal support he was able rapidly to bring together an efficient body of working geologists, with and through whom he soon began to throw light upon the rocks of India. Of the value of his services, as exhibited in the publications of the Survey, Dr. Oldham has repeatedly received very high testimony from the scientific world. To appreciate fully what he has effected, one should have experience of the position, where every means, material and personal, had to be formed or imported; and further, one should see what is only known to those present, the very valuable library and the extensive collections brought together by his care. Due honour paid to the intelligent liberality of the Government of India, it is to Dr. Oldham, whether as Superintendent of the Geological Survey, or as President of the Asiatic Society of Bengal, more than to any other man, that Calcutta owes the magnificent museum-building it can now boast of. All this he now leaves to his colleagues and successors. Failing health compels him to retire from the service, and leave the country before he could give form and unity to his labours. Those who reap where he has sown should ever remember the great debt they owe to Dr. Oldham.

NOTES ON THE AGE OF SOME FOSSIL FLORAS OF INDIA, *by* OTTOKAR FEISTMANTEL, M. D.,
*Geological Survey of India.*

I AND II.

WHILE preparing detailed descriptions and investigations of the several fossil floras of India, with drawings of all the most important specimens for the Palæontologia Indica, I think it best to give brief outlines in this place of the results I have obtained from the study. Though persuaded of their interest, both general and special, I must not presume that every naturalist can and will take the time and trouble to study those detailed investigations. All may, however, easily master the results if offered to them in this short form.

It is necessary to preface these papers with a notice of the formations to which they refer. The best known, because almost the only fossiliferous, rock-series in the peninsular area of India, is that usually spoken of collectively as the plant-bearing series. This is an awkward designation; and I will at once adopt instead the name GONDWÁNA series or system, to be understood in the same wide sense as when we speak of the Jurassic or Silurian series or system. The name was proposed some years ago by Mr. Medlicott, and has since been more or less current on the survey; it has been once used in print by Mr. H. F. Blanford in his little work on the Physical Geology of India. We have in India important coal-bearing strata of cretaceous and nummulitic age, quite distinct from the Gondwána series, to the flora of which we will first call attention in these papers as of more pressing interest.

From Raniganj, on the western edge of the Delta of the Ganges, these formations stretch in detached basins up the valley of the Damuda, between the crystalline masses of Chutia Nagpur and Hazaribagh. Smaller patches also occur on the northern portion of the latter area, in some of the valleys, and along the border of the gneiss towards the plains of the Ganges. The Rajmahal area belongs to this position. From the head of the Damuda they stretch into the valley of the Sone, spreading out there into the wide basin of South Rewah. A narrow band of the topmost group, passing by Jabalpur, connects this area, across the gneissic mass forming the watershed of the peninsula, with the large basin in the Satpura range, on the west side of which, along the Moran river, the stratified series passes *in force beneath the trap rocks of the Deccan.* Some few inliers have been detected beneath *the trap further to the west in the Narbada valley, as about Barwai. Throughout the entire* course along the Sone and Narbada valleys, the boundary of the Gondwána series runs close to the *great Vindhyan plateau, from the scarp of which it is everywhere separated by a* varying belt of gneissic or schistose rocks.

Far removed to the west, but still within the rock-area of the Indian peninsula, plant-bearing beds of the Gondwána age have long been known to occur in Kach.

This northern region of the Gondwána deposits, stretching obliquely across India from east-north-east to west-south-west, has two extensions to the south. The South Rewah basin is continuous across the watershed of the Sone and Mahanadi rivers, through Sirgujah into Raigarh and Hingir, towards the Talchir coal-field and the Atgarh area below Katák. On the west, in the Satpuras, the Gondwána rocks occupy the watershed between the Narbada and the basin of the Godavari. It is doubtful whether they were ever continuous in this direction, but they here at least come into proximity to the deposits of the same age at Nagpur, and extending from here down the valleys of the Wardah and Godavari to Rajamandri. From the Delta of the Godavari there occur detached patches of these rocks along the coast of the Karnatik to Trichinopoli, fringing the great expanse of gneissic rocks forming the high land of the interior.

There is only one extra-peninsular region in India where rocks of this age have been identified—along the base of the Eastern Himalaya, in Sikhim and Upper Assam.

The following table exhibits the various groups into which the Gondwána series is at present tentatively divided in the several regions:—

| Bengal. | South Rewah. | Satpura. | Godavari. | Karnatik. | Kach. | E. Himalaya. |
|---|---|---|---|---|---|---|
| Rajmahal. | Jabalpur. | Jabalpur. | Rajmahal. | Rajmahal. | Kach. | |
| | | Mahadeva. | | | | |
| Panchet. | | Almod. | | | | |
| Damuda { Raniganj. | Pali. | Bijori. | Kamthi. | | | |
| Damuda { Ironstone shales. | | Motur. | | | | |
| Damuda { Barakar. | Barakar. | Barakar. | Barakar. | | | Damuda |
| Talchir. | Talchir. | Talchir. | Talchir. | | | |
| Gneiss. | Gneiss. | Gneiss. | Vindhyans and gneiss. | Gneiss. | | |

Most of these strata contain only plant remains. Some widely separated localities have also yielded a few vertebrate fossils of fish and reptiles, for which various ages have been assigned—palæozoic, triassic, and liassic. It is only in Kach and on the east coast of the peninsula that the *upper members* of the series are found associated with beds containing a well-marked marine molluscan fauna; and these have been taken to give the horizon of these groups. The plant beds of Kach alternate with and overlie strata having an upper jurassic fauna; and a similar association of the Rajmahal group has been found near Rajamandri and in parts of the Karnatik. While, at Trichinopoli, plant beds of about the same horizon underlie the well-known upper cretaceous rocks of that region. The evidence of the plants will be seen to indicate a much lower homotaxeous position for these strata; thus establishing a marked palæontological discordance between the marine and terrestrial organisms of this geological epoch in this region. In such cases we must only say, the flora of this or that locality (or stratum) is of such an age, and was still growing on the coast, when already a younger fauna (but of the same epoch) was living in the sea. This is the only way to explain these so-called palæontological contradictions between the fauna and flora of the same strata.

My examination of the collections has so far indicated the existence of five distinctive floras in the following horizons of the Gondwána system:—

1.—Kach (in Kach).

2.—Rajmahal (in different places).

3.—Panchet (in different places).

4.—Damuda (in different places), including the Raniganj (Kamthi), Iron-Shale, and Barakar groups.

5.—Talchir.

It is, of course, possible that further research may necessitate modifications or additions to this classification. The present papers contain my observations on the flora of the Kach beds, in Kach, and of the Rajmahal group in the Rajmahal Hills, and at Kolapilli in the Godavari district.

## I.—Flora of the Kach Series (Cutch).

The flora of Kach, in comparison with the animal remains from the same formations, is rather poor, especially in the number of genera and species. There are, however, enough characteristic genera and species for determination of the age of the flora as a whole, though it is not quite so easy to determine the age at each locality with the same accuracy.

For my purpose it will be sufficient and most useful to represent the flora first in a general systematical review, and then may follow the localities with their characteristic species and their probable correlation.

### A.—Acotyledones Cryptogamæ.

#### I.—*Algæ.*

Of this family I have not met with any specimen, but Mr. Morris, in Captain Grant's *Geology of Kach*, describes a *Fucoides dichotomus*, Morr. Although I am quite unable to form an opinion as to whether Mr. Morris is right or not (because I have not seen the original specimen), I may remark that there is no objection to take it so, as from the same strata of other places (England) *Algæ* are mentioned. I would only add that if it is an *Alga*, it is a *Chondrites*, with the same specific name.

Locality not indicated.

#### II.—*Filices.*

Ferns are not very frequent, but some most characteristic genera and species occur. Already in the representatives of this family, we can see the character of the strata. At least we must, on the first view, say that they are Mesozoic, the species may then determine nearer.

##### 1. Order, *Tæniopterides.*

As we will also find in the Rajmahal group, this order is abundantly developed, but represented by some different species. This is the first difference we may notice between these two floras.

In the division of this order, I follow the newest by Mr. Schimper—

*a.*—*Tæniopteris*, Bgt., mostly Palæozoic.
*b.*—*Angiopteridium*, Schimp. Mesozoic.
*c.*—*Oleandridium*, Schimp. Mesozoic.
*d.*—*Macrotæniopteris*, Schimp. Mesozoic.
*e.*—*Danæopsis*, Heer.
*f.*—*Danaites*, Göppt.

Our species are—

*a.*—*Oleandridium vittatum*, Schimp. (*Tæniopteris vittata* Bgt.) Some specimens agreeing quite with Brongniart's drawings and those of Lindley and Hutton, also with those of Young and Bird, Phillips, &c., from the English Oolite (Scarborough), are known from Kukurbit, in a grey sandy clay. It is an important species.

*b.*—*Tæniopteris densinervis*, Fstm. The fragment from which this species is made I take to be a real *Tæniopteris*, Bgt.

Locality: Kukurbit.

##### 2. Order, *Pecopterides.*

Some fragments occur; a few of them are of considerable importance.

*a.*—*Alethopteris*, *Whitbyensis*, Göpp. *Pecopteris Whitbyensis*, L. and H., Tab. 134 (Foss. flor. of Great Britain.)

Some fragments of a true *Alethopteris*, Göppt. (leaflets attached by the whole base and connected together). I could only identify with this species, which occurs mostly in the English Oolite, although it has been also found in the Liassic strata. This species is often mentioned in books under the most different synonyms. In my detailed descriptions I have brought them all into the relation I think most correct.

Locality: Doodaee, in a reddish-grey soft clay.

*b.—Pecopteris (cyatheides) tenera*, Fstm. A small fragment of a pinna I place here, but it is of no special importance.

Locality: the same.

3. Order, *Neuropterides.*

It is with Mr. Schimper that I agree in placing the following genus and species in this order, while by other authors it has been assigned to a quite different order. To discuss this point here would be out of place. The genus is *Pachypteris*, Bgt., which I take in Brongniart's sense, and unite with it some *Sphenopteris* and *Neuropteris* of Phillips, *Dichopteris* of Zigno, and *Scleropteris*, ex. p. Saporta. It is of Jurassic age.

*a.—Pachypteris specifica*, Fstm. There is no doubt that the specimen I have so named belongs to the same genus as Brongniart described. It is very near Brongniart's species of *Pachypteris*, also to *Dichopteris visianica*, Zigno.

These species, with which ours agree, are lower Oolitic (Scarborough and Italy).

*Locality:* Bhoojooree, in a soft reddish clay.

*b.—Pachypteris brevipinnata.* This form, which I believe to be the same genus, I so name on account of its shorter pinnæ. Locality.—Kukurbit.

4.—Order, *Cyclopterides.*

Genus, *Actinopteris.*

Some peculiar, orbicular, and radially striated forms from Bayreuth M. Göppert, described first as *Cyclopt. peltata*, Göpp., and we find this locality mentioned as Keuper. But later, from the researches of M. Schenk, these localities near Bayreuth (Culmbach, Veithlahm) are determined as belonging to the interposed strata (between Keuper and Lias) called Rhætic. This species, too, was independently changed into *Actinopteris peltata*, Schnk. I have now found this form in the Kach series. There are three specimens quite agreeing with all the drawings; so I am, no doubt, correct in the identification, although I am still quite unable to say anything distinct about the nature of these fossils. Prof. Schimper regards them as pseudo-fossils, formed by infiltration; but on this supposition their constant form and limited occurrence in the Juro-triassic epoch, most near the division boundary, would be inexplicable.

*Locality*: Near Gooneri; in gray, sandy clay, as at Kukurbit. If I do not accept this locality to be Rhætic, I must at least accept this fossil as an indication of a lower horizon than has as yet been assigned to these plant beds.

B.—COTYLEDONES PHANEROGAMÆ.

I.—*Cycadeæ.*

This family, which was in India generally very abundant in the floras of Jurassic times, has the most representatives also in the Kach series. We will, however, see that the representation here is in a different manner than in the Rajmahal beds; and this is another point of difference between these series, which were formerly thought identical.

1.—Genus *Ptilophyllum*, Morr.

I take this name of Morris, and not the later *Palæozamia*, Endl., because our genus is indeed quite different from all others, and therefore also from *Palæozamia*, as Schimper and Saporta have also lately shown.

This *Ptilophyllum* is a truly Indian type, forming the only link between some Indian local floras; and we can ascertain independently that the *Ptilophyllum (Palæozamia)* bearing beds are all of Jurassic (lower) age.*

* It may be well to note that I use the classification making the Jurassic to include Lias

*a.—Ptilophyllum Cutchense*, Morr. (*Palæozamia Cutchensis*, Morr. and Oldh.) This is the predominant form, with shorter and more obtuse leaflets. I distinguish several varieties which I need not enumerate here. Locality: Kukurbit and Bhoojooree.

*b.—Ptilophyllum acutifolium*, Morr. Mr. Morris, in Captain Grant's Geology (Transactions, Geolog. Soc., 1840, Vol. V, 2 Ser., p. xxi, f. 123), figures several specimens, but I have observed only one. Locality: Bhoojooree.

2.—Genus *Otozamites*, Braun.

*c.—Otozamites contiguus*, Fstm. Some fern-like forms have been formerly placed as *Otopteris*; but I believe it is best to take them all still as *Otozamites*, Braun; it will at least avoid confusion.

The above species is one of those with short *pinnulæ*. Locality: Kukurbit.

*d.—Otozamites imbricatus*, Fstm. A species with longer *pinnulæ*, which are so inserted on the *rhachis* that they are imbricated. Locality.—Loharia; in ferruginous fine-grained sandstone.

*e.—Otozamites* cf. *Goldiaei*, Bgt. This is one of the groups with long *pinnulæ*; and I consider our specimen closely allied to Brongniart's species from the English Oolite; and so a species of more importance than the others. Locality.—Kukurbit.

3.—Genus *Cycadites*, Bgt.

*f.—Cycadites Cutchensis*, Fstm. A very delicate species, with the distinct midrib of *Cycadites*. Very close to *Cycadites zamioides*, Leckenb., differing only by the insertion of the leaflets on the base. This latter is also an Oolitic species from England (Scarborough). Locality: Kukurbit.

4.—Genus *Williamsonia*, Carr.

There are three species of a fossil from Kukurbit, brought by Mr. W. T. Blanford, which I place in the genus *Williamsonia*, Carr., from the English Oolite (Linn. Transact., Vol. XXVI, p. 680. Phillip's Yorkshire, iii edit., 1875, p. 227, Pl. XXIV, f. 5), and which I will describe as *Williams. Blanfordi*, Fstm.

Of less importance is *Cycadolepis*, Sap., which occurs also near Bhoojooree in one specimen, and to which I give the specific name *Cycadol. pilosa*, Fstm.

II.—*Coniferæ.*

Among the remains of this class are again some very important species for the determination of age, as they in general are very characteristic of the strata in which they occur.

1.—Genus *Palissya*.

From three localities we have got coniferous branches, which I place without hesitation in this genus, because they have its peculiar characters.

*a.—Palissya Bhojoorensis*, Fstm. This species I think different by some marks from *Palissya Brauni*, Endl., and from that occurring in the Rajmahal series, *P. Oldhami*, Fstm.; so I name it as above. Locality. Bhoojooree; in reddish soft clay.

*b.—Palissya* sp. like that from the Rajmahal series, and also from the Jabalpur group, which is probably of the same horizon.

This specimen is from Thrombow, and I think perhaps this locality is lower in age than the others. This species signifies again that we should take for the Kach series a lower age than has lately been given to it. The other species of ferns and the other *coniferæ* suggest the separation of the Kach from the Rajmahal series.

Two other branchlets occur, which I would consider also as *Palissya*, Endl. They resemble very much Phillips' *Taxites laxus*, Phill., which, however, seems also to be a *Palissya:* and I would designate it as *Palissya laxa*, Phill., sp.

2.—GENUS, *Pachyphyllum* Bgt.

*a.—Pachyphyllum divaricatum*, Fstm.—A coniferous branch, agreeing quite with *Cryptomerites divaricatus*, Bunb., from Scarborough; but I believe this fossil more correctly placed in the genus *Pachyphyllum*, Schimp., as I have also placed our specimen.

Locality: Kukurbit.

3.—*Echinostrobus*, Schimp.

*a.—Echinostrobus expansus*, Schimp. The most frequent, and also quite characteristic coniferous plant, is a form with thin and dichotomous branches, having the general aspect of a *Thuya* or *Cupressus*, and which also at first was described as *Thuytes expansus*, Stbg. (Phillips). It is now placed by Schimper in his new genus *Echinostrobus*, Schimp. This species also is thus identical with a species from the English Oolite.

Locality: Kukurbit, frequent.

4.—*Scales* of fossil cones.

Very remarkable also are some rather frequent fossils, which on the first view must be recognized as scales of fossil cones. If we look after analogies in existing literature, we find some quite the same in Phillips' Geology of Yorkshire, and recently in Mr. Carruthers' paper on some undescribed coniferous fruits from secondary rocks of Britain (Geo. Mag., 1869). Phillips mentioned this fossil as "winged seed"; while Mr. Carruthers described them with *Araucarites* as scales of cones of this genus. Our fossils are of the same kind.

Locality: Pretty frequent at Kukurbit.

This may, therefore, be the general view of fossil plant remains from Kach:—Generally considered, the flora declares itself at once as Jurassic. The particular horizon must be determined by the most characteristic fossils. These are—*Oleandridium* (*Tæniopteris*) *vittatum*, Schimp. *Alethopteris Whitbyensis*, Gopp.; Gen. *Pachypteris*, Bgt.; *Otozamites* cf. *Goldiæi*, Bgt.; *Cycadites Kachensis*, Fstm. (*Palissya*, Endl.); *Pachyphyllum divaricatum*, Fstm.; *Echinostrobus expansus*, Schimp. *Scales*.

All these fossils occur in the English Oolite of Scarborough and Whitby: and the same plants from Jurassic strata in Kach may be placed generally in the same age. While some localities seem to indicate a lower horizon, we can say that the Jurassic strata of Kach generally are of an Oolitic age; and it is of a lower Oolitic horizon, corresponding to the strata seen on the Yorkshire coast at Scarborough and Whitby, with which our flora has about ten genera and species in common. With the Oolitic flora of Italy and France there are only some genera in common; as is also the case between those floras and the English Oolitic flora. With the Rajmahal series, as we will see, the Kach beds have only about three or four species in common, while, moreover, there is a great difference in the most characteristic forms.

The localities here mentioned are (taking the supposed oldest first) :—

1.—Near Gooneri, with *Actinopteris* (Schenk)-like forms; gray sandy clay.

2.—Thrombow, with *Palissya*, like the same from the Rajmahal series and the Jabalpur group; in the same gray sandy clay.

These two indicate a lower age, and perhaps represent the Rajmahal series in Kach.

3.—Kukurbit, with most of the characteristic types: *Oleandridium, Otozamites, Cycadites, Palissya, Pachyphyllum, Echinostrobus* (*Thuytes*), fossil *scales*, all with oolitic species; in gray sandy clay.

4.—Bhoojooree, with *Pachypteris specifica;* in a reddish soft clay.

5.—Doodace, with *Alethopteris Whitbyensis*, Göpp.; in a reddish-gray soft clay.

These three, it can scarcely be doubted, are of lower oolitic age.

6. Loharia, with *Otozamites imbricatus*, Fstm.; in a ferruginous sandstone.

All of these can be determined with more or less accuracy as lower Oolitic, excepting Loharia, which is not so distinct. But generally a lower oolitic age must be taken for them; only the two localities, Gooneri and Thrombow, indicate a lower horizon.

As I have already mentioned, there seems to be a "*palæontological contradiction*" between the evidence from the animal and from the plant remains. The latter occur in the upper groups of the local Jurassic series as described by Mr. Wynne, the marine fauna occurring in the lower groups. According to Dr. Waagen's researches on the *Ammonite* fauna, this is not older than Bathonian; and yet the plants, which are from a higher horizon, indicate generally an age as old as the Bathonian or Bath-oolite, and some of them a still older horizon.

Such are the palæontological facts regarding which we can only say that plants of lower oolitic age still flourished in this region after that animals of younger strata had been living in the adjoining sea. It would seem, moreover, from the fact that *Ptilophyllum*, Morr., and other species occur also in the Rajmahal series, that the flora of Kach, though generally oolitic, had an earlier existence in India than in the strata of England.

## II.—Flora of the Rajmahal Series (in the Rajmahal Hills Godaveri District).

The flora of the Rajmahal series in general, and especially that of these strata as typically seen in the Rajmahal hills, is more abundant than the Kach flora, both as regards the number of specimens as well as of genera and species. I will therefore first discuss shortly the flora as exhibited in this region, and having established the typical forms here, we can recognize them in other places.

The fossil plant-remains of the Rajmahal series in the Rajmahal hills have formed already the object of a valuable work begun by Mr. Oldham and Prof. Morris, but of

## A. CRYPTOGAMÆ ACOTYLEDONES.

### I.—*Equisetaceæ.*

Perhaps in all formations characteristic forms of this order occurred. We have from here *Equisetum*, called *Equisetum Rajmahalense*, Schimp, (Oldh., Morr. Pl. II, f. 2-3. Pl. XXXV, f. 3-4), which is near to some liassic and rhœtic forms. In Kach, as we saw, no *Equisetaceæ* were observed.

### II.—*Filices.*

These are pretty frequent in the Rajmahal hills, with some most characteristic forms.

#### 1.—Order *Sphenopteridæ.*

*a.—Sphenopteris*, Bgt.: by *Sphenopt. Hislopi*, Oldh. and Morr. Pl. XXXI; *Sphenopt. membranosa*, Fstm. and *Sphenopt. arguta*, L. and H.; Pl. XXXII (O. and M.); this is an Oolitic species in England.

*b.—Dicksonia:* by *Dicks. Bindrabunensis*, Fstm. Pl. XXXVII, f. 2-2a; this is a *Sphenopteris*-like fossil with a fructification by which it must be placed as *Dicksonia.*

*c.—Hymenophyllites*, Bgt., by *Hymenophyllites Bunburyanus*, Fstm. (*Sphenopt. Bunburyana*, Oldh. and Morr. Pl. XXXII f. 5-6.)

#### 2.—Order *Neuropterides.*

*a.—Cyclopteris*, Bgt. On Plate XXXVI (Oldh. and Mor.) (not yet published) are drawn two fragments of a *Cyclopteris*-like leaf not well defined. Later I got two others, one of them quite distinct, with the characters of a *Cyclopteris*, which, therefore, may be called *Cyclopteris Oldhami*, Fstm., Pl. XXXVII, f. 5-6.

*b.—Thinnfeldia*, Ettgh. A very interesting genus already known by A. Braun (1840), but described as *Kirchneria* Br., and later by still other names. The systematical position is, following Mr. Schimper, with the *Neuropterideæ*, in which I must agree with him. The geological horizons for this genus are Lias and Rhœtic. We possess from Buskoghat a specimen of a plant which I took at once to be a *Thinnfeldia;* and this has been confirmed by the discovery of another well marked specimen near Burio, so that I will describe this plant as *Thinnfeldia indica*, Fstm. Pl. XXXIX f. 1-1a, Pl. XLVI f. 1-2-2a.

#### 3.—Order *Pecopterides.*

There are some quite distinctive forms for the Rajmahal series, and also for the characters belonging to this family.

*a.—Pecopteris gleichenoides*, Oldh. and Morr., Pl. XXV, XXVI; placed by Schimper as *Gleichenites*, and called *Gl. Bindrabunensis*, Schimp.; is very frequent and typical for these strata. Schimper may be right. Mr. Oldham also placed this species as *Gleichenites.*

*b.—Pecopteris (Alethopt.) indica*, Oldh. and Morr., Pl. XXVII, is indeed an *Alethopteris* with the same specific name. It is allied to *Asplenites Rösserti*, Schenk, from the Rhœtic (Bavaria), and to some other species of *Alethopteris;* important. *Pecopt. salicifolia*, Morr., is also to be placed here.

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* The figures which M.M. Oldham and Morris have already given in their work I will mark, "Oldh., Morr., Pl. , fig. "; those to be drawn in my continuation of that work are here marked as "Fstm., Pl. fig. ."

† Besides the plant remains I am going to describe, there are also fossil silicified woods pretty abundant, which, however, I am unable to mention here, as they want more examination. I will describe them later together with others of the same kind.

*c.—Pecopteris* (*Asplenites*) *macrocarpa*, Oldh. and Morr., Pl. XXVIII, is an *Asplenites* very near to *Asplenites Ottonis*, Schimp., also from the Rhœtic (Bavaria); important.

*d.—Pecopteris lobata*, Oldh. and Morr. Pl. XXIX, XXX, pretty frequent; it may retain this name; it seems an Indian type.

4.—Order *Tæniopterides.*

This family gives one of the chief characters of the Rajmahal series, especially in the Rajmahal hills; there are very frequent large and interesting forms which are very important for the determination of the age.

*a.—Macrotæniopteris* (*Tæniopteris*) *lata*, Schimp., (Oldh. and Morr.) Pl. I, II, IV, *Tæniopteris musæfolia* (Oldh.) Schimp., which are not really different, represent the character of this family, being very near to *Tæniopt.* (*Macrotæniopt.*) *gigantea*, Schimp., from the Rhœtic.

*b.—Tæniopt.* (*Angiopteridium*) *McClellandi*, Oldh. and Morr., Pl. VI, (*Tæniopt. spathulata*, McClell.), being near to *Angiopteridium* (*Tæniopt.*) *Münsteri*, Schimp., from the Rhœtic, these two fossils indicate a lower age for this series than that hitherto supposed.

*c.—Tæniopt. ovata*, Schimp., described as *Tæniopt. ovalis* (Oldh. and Morr.), but different, as I find by the denticulation of the margin. O. M. Pl. III; Fstm. Pl. XXXVII, f. 1.

*d.—Macrotæniopt. Morrisi*, Oldh., is also a separate species. O. M. Pl. III, IV.

*e.—Danaopsis Rajmahalensis*, Fstm. Pl. XXXVIII. 4. The essential characters of this very interesting genus are, I believe, exhibited in this species.

In the *Cryptogamæ* we may, therefore, note as important *Equisetum Rajmahalense*, Schimp., *Thinnfeldia indica*, Fstm., *Alethopteris indica*, Oldh. and Morr., *Alethopt. macrocarpa*, Oldh. and Morr., *Macrotæniopteris lata*, Oldh., and *Angiopteridium McClellandi*, Oldh. and Morr.

B.—PHANEROGAMÆ—COTYLEDONES.

In this class we find another marked character of the Rajmahal series, by which again this flora differs quite distinctly from that of the Kach series.

*a.—Pterophyllum*, Bgt. The most developed genus, with a great variety of forms, of which the most characteristic are *Pterophyllum carterianum*, Oldh., *Pterophyll. Morrisianum*, Oldh., *Pterophyllum princeps*, Oldh. and Morr. (which is quite near to *Pteroph. Braunsi*, Schenk, from the Rhœtic), *Pterophyll. Rajmahalense*, Morr. &c., as they have been described and figured by Oldham and Morris. Pl. X, XVIII.

*b.—Ptilophyllum*, Morr. About this I have already said that I take this name instead of *Palæozamia*, Endl., observing it as an Indian type, and therefore as a distinct genus; this genus is known both in the Kach and the Rajmahal series; and also the same species occur in both; but while *Ptiloph. Cutchense*, Morr., prevails in Kach, *Ptiloph. acutifolium*, Morr., is the most abundant in the Rajmahal series. *Ptilophyll. rigidum*, Schimp., I take to be identical with this latter, and think *Ptilophyll.* (*Palæozamia*) *affine*, n. sp., not very far from *Ptilophyll. Cutchense*, Schimp. As varieties I distinguish here also *Ptiloph. acutifolium* var *maximum* and *Ptiloph. Cutchense* var *minimum*; this genus constitutes a connective form between these two rock-series, belonging to the same great geological epoch; it is Jurassic.

*c.—Otozamites* Braun. In this genus I put some species, which in the first description of the Rajmahal series by MM. Oldham and Morris were also described as *Palæozamia* Endl., O. M. Pl. XIX. Their *Otopteris*-like *habitus* is so distinct, especially in the disposition of their veins, that at first I thought it right to place them with *Otopteris*, Schenk. It seems best, however, following MM. de Zigno and Saporta, to abandon this old genus, and to take all *Otopteris* forms as *Otozamites*, because they have more characters of the *Zamieæ;* so these *Otopteris*-like fossils from the Rajmahal hills (which stood formerly as *Palæozamia*) must be put to *Otozamites*, Braun. The species are *Otozamites abbreviatus*, Fstm. (*Palæozamia bengalensis*, Oldh. and Morr.), *Otozamites bengalensis*, Schimp.; it is near *Palæozamia brevifolia*, Braun, or *Otopteris Bucklandi*, Schimp., but Mr. Schimper considers it different by its more obtuse leaflets, and names it as above.

*d.—Zamites*, Bgt. Of this genus, we have two specimens, pretty well preserved. I call the species *Zamites proximus*, Fstm., as it is very near to a living *Zamia*. Fstm. Pl. XLI. f. 1-2.

*e.—Dictyozamites*, Oldham. Quite a peculiar genus in general, and a marked Indian type; we only know it in the Rajmahal series. It was at first described and characterized as a *Dictyopteris*, Gutb., and as *Dictyopt. falcata*, Morr., and *Dictyopt. falcata*, var. *obtusifolia*, Morr., by Mr. Morris in the original description of Rajmahal plants in the Palæontologia Indica, 1862, Pl. XXIV. Although at first of the same view (Memoirs Geological Survey of India, II, p. 320), Mr. Oldham, in the description of the Rajmahal plants, p. 40, developed another and more correct opinion about this fossil, taking it as belonging to the *Cycadeaceæ* (*Zamieæ*) near *Otozamites*, Braun, and proposed a new generic name, *Dictyozamites*, with its diagnosis, which I fully adopt. I propose the specific name *Dictyozamites indicus*, *Fstm.*, taking both varieties as the same. It was originally known only from *Amrapara;* lately I found it also near Murrero. Outside of the Rajmahal hills we know it also in some other places.

### 2. *Cycadeæ.*

*a.—Cycadites*, Brgt. The occurrence of true *Cycadeæ* is also of importance for the determination of age, because they indicate always a lower horizon in the Jurassic series. Fossils of this genus are very abundant in the Rajmahal series. MM. Oldham and Morris have described three species; but I believe there are only two, *Cycadites Rajmahalensis*, Oldh., and *Cycadites confertus*, Morr., putting the third, *Cycadites Blanfordianus*, Oldh., with this latter, O. M. Pl. VII, IX.

Some fruit-like fossils I recognize as belonging to the genus *Williamsonia*, Carr.; they are very similar to those in Phillips' Geology of Yorkshire, 3rd Ed., 1875, Pl. XXIV, f. 2, 3, 4, 5, from the lower sandstones (lower portion of lower Oolite) of Whitby.

Besides these, there are also some cycadeous stems and fructifications, which, however, need no further mention.

### 3. *Coniferæ.*

In this family we find some well marked forms, serving to indicate the age of the Rajmahal series, and also as characteristic of that formation.

#### 1.—Genus *Palissya*, Endl.

Two species occur, one pretty frequently typical of the Rajmahal series.

*Palissya Oldhami*, Fstm., O. M. XXXIII, is a form like *Palissya Brauni*, Endl., from Rhœtic strata; it is the same form as mentioned already in the Kach series from Thrombow.

Another form I call ***Palissya pectinea***, Fstm., Fstm. XLV. which is very frequent; it has lately been found also in other places, which I take to belong to the Rajmahal series. MM. Oldham and Morris have figured the first as ***Toxodites indicus***, and the second as ***Cunninghamites confertus***.

2. *Cheirolepis*, Schimp.

Some very tender-leaved branchlets, first described as *Araucarites gracilis*, n. sp., O. M. Pl. XXXIII, XXXV. and which have a *Lycopodites*-like aspect, must, I believe, be placed in this genus. I name them ***Cheirolepis indica***, Fstm. I may at once mention that no *Lycopodites* is known higher than in the Permian; all *Lycopodites*-like plants in the newer strata being *coniferous* plants.

3. *Echinostrobus*, Schimp.

I have already said in the preceding note on the Kach flora, that some species of the genus *Thuytes*, Ung. (which have been sometimes also called *Arthrotaxites*, Ung. and others), have been shown by Prof. Schimper to be *Echinostrobus*, Schimp. In the Rajmahal series there occur some branches which must be so placed.

*Echinostrobus Rajmahalensis*, Fstm. O. M. Pl. XXXII. 8. Fstm. XLV.: I call by this name some branches resembling the now disused species, *Baliostichus ornatus*, Stbg., *Arthrotaxites Baliostichus*, Ung., and *Arthrotaxites Frischmanum*, Ung., but which three form, as I think, only one species. Our Rajmahal specimens are, however, a little different.

Such is the flora of the Rajmahal series in the original area, so far as now determined. I estimate the whole number of good species as about fifty. The description of the flora of this series, as the continuation and conclusion of the valuable work of MM. Oldham and Morris, illustrated by eleven additional plates, will, I hope, be published as soon as possible after the Flora of Kach, now in the press.

In taking a general view of the Flora of the Rajmahal series in the Rajmahal hills, we may point out the following plants as the most important forms :—

*1st.*—As characteristic of the formation :—

*a.*—***Alethopteris indica***, Oldh. and Morr.
*b.*—***Asplenites macrocarpus***, Oldh. and Morr.
*c.*—***Gleichenites (Cyatheides) Bindrabunensis***, Schimp.
*d.*—Some species of *Tæniopteris*, Bgt..
*e.*—The frequent occurrence of the genus ***Pterophyllum***, Bgt.
*f.*—***Dictyozamites indicus***, Fstm.
*g.*—***Palissya pectinea***, Fstm.

*2nd.*—For determination of the age :—

*a.*—***Equisetum Rajmahalense***, Schimp.
*b.*—***Alethopteris indica***, Oldh. and Morr.
*c.*—***Asplenites macrocarpus***, Oldh. and Morr.
*d.*—***Thinnfeldia indica***, Fstm.
*e.*—***Macrotæniopteris lata***, Schimp.
*f.*—***Angiopteridium Mcclellandi***, Schimp.
*g.*—The frequent occurrence of ***Pterophyllum***, especially ***Pt. princeps***, Oldh.
*h.*—***Otozamites brevifolius***, Br. (*Otoz. Bengalensis*, Schimp).
*i.*—The true *Cycadites*, Bgt., and ***Palissya Oldhami***, Fstm. (near ***Palissya Brauni***, Endl.)

***All the plants enumerated in this 2nd list are of such a facies that they indicate at once a lower zone of the*** Jurassic ***period, and I have no hesitation in assigning to them a*** Liassic ***age.*** At first, these plants were considered as oolitic. M. de Zigno, in a written consideration, which is in my hands, dated 1861, and later in a paper, Sopra i depositi di piante fossili dell' America settentrionalle, delle Inde e del Australia, etc, Padova, 1865 (of which there is a Report in Leonhard and Geinitz n. Jahrb. 1866, p. 381), regards them rather as Liassic. In the Vienna Jahrb, der Geolog. Reichsanst., 1861-62, Verhandl., p. 80, we find the Rajmahal fossils mentioned as agreeing with the Austrian Keuper plants. Mr. Ettingshausen, in his "Farrenkrauter der Jetztwelt," p. 22, remarks of *Tæniopt. lata* and *Taen. Morrisi* quite distinctly: "In formatione *Lias* dicta ad Bindrabun Bengaliæ." We may therefore adopt, as the result of our special study confirming the opinions of the several authors, that these Rajmahal strata are to be taken as Liassic.

Mr. Schimper, however, in Vol. III of his Paléontolog. végét., has put the greatest number of our Rajmahal fossils in the oolitic period; while one of the same, *Equisetum Rajmahalense*, Schimp., occurring in the same strata with the others, he puts as Rhœtic, which, of course, is contradictory. This is still more remarkable when we find Mr. Schimper placing also the *Glossopteris* and *Phyllotheca* of the Damuda series in the Oolitic period.

It remains now only to enumerate the localities of the fossil plants I have examined, or where they are said to occur. There are twelve localities known, in an alphabetical order, as below:—

1, Amrapura; 2, Bindrabun; 3, Burio; 4, Busko Ghat; 5, Ghutiari; 6, Jamkoondih; 7, Murero; 8, Muchwa Pass; 9, Onthea; 10, Salempoor; 11, Shahabad; 12, Sooroojbera.

The total number of species being taken as fifty, the number known from the several localities is as follows:—

1-5, 2-32, 3-9, 4-5, 5-2, 6-2, 7-4, 8-2, 9-4, 10-1, 11-1, 12-1.

The greatest proportion is in No. 2, Bindrabun, with thirty-two species; the next is No. 3, Burio, with nine.

### *Note on the age of the flora of some places in the Godavari District, especially of the sandstones of Kolapilli.*

In the Records of the Geological Survey, 1871 and 1872, Mr. W. T. Blanford has published a paper in two parts on some plant-bearing sandstones of the Godavari valley, and descriptions of others in the same district (Records, Vol. IV, p. 107, Vol. V, p. 23, Vol. IV, p. 49)

All the places Mr. Blanford mentions, and from which he has got fossil plants, he has recognized as belonging to the Damuda series and to the Kamthi group (upper portion of Damudas in general) on account of the occurrence of *Glossopteris* and *Vertebraria* in the characteristic forms for those beds. This is indeed so; and our Museum contains several sets of fossil plants, from localities in the Godavari District (from the lower part of the river valley) which are at once to be recognized as plants of the Kamthi or Raniganj group.

But we have got also from another locality, Kolapilli, near Ellore, discovered by Mr. King, a set of plants which certainly belong to another group and another age.

The plants from this locality are preserved in a very fine sandstone of a yellow-brown colour (ferruginous). They are pretty numerous, but do not represent many species; sufficient, however, to determine the age of the flora. The following systematical enumeration will enable us to compare these fossils with others already described and determined.

### I.—*Equisetaceæ.*

Wanting.

### II.—*Filices.*

1.—***Alethopteris indica***, Oldh. and Morr.: some very characteristic specimens quite like the Rajmahal form, and also like ***Asplenites Rosserti***, Schenk.

2.—***Asplenites macrocarpus***, Oldh. and Morr.: frequent, very closely allied to ***Asplenites Ottonis***, Schimp.

3.—*Gleichenites Bindrabunensis*, Schimp., (*Pecopteris gleichenites*), Oldh. and Morr.: a fragmentary specimen.

4.—*Tæniopteris* (*Angiopteridium*) *spathulata*, McCl.: a fragment of a *Tæniopteris*, agreeing well with fig. 7 on Pl. VI, Oldh. and Morr., Rajmahal Flora.

5.—*Tæniopteris* (*Angiopteridium*) *ensis*, Oldh. and Morr. Two specimens I believe belong to this species of the Rajmahal Hills.

### III.—*Cycadeæ.*

1.—*Pterophyllum Morrisianum*, Oldh., one or two specimens, one pretty large.

2.—*Pterophyllum carterianum*, Oldh. A very frequent species.

3.—*Pterophyllum* comp. distans, Morr. (*Hislopianum*, Oldh.) The specimen recalls also the *Pteroph. Braunianum*, Göpp.

4.—*Ptilophyllum* (*Palæozamia*) *acutifolium*, Morr. The common form. Pretty frequent.

5.—*Ptilophyllum cutchense*, Morr. This species is also represented by some specimens.

6.—*Dictyozamites indicus*, Fstm., formerly *Dictyopteris falcata*, Morr. Of this very interesting and curious fossil, the systematic position of which, however, has not yet been quite determined, but is provisionally taken as a *Cycadea* near *Otozamites* Braun, there occur some specimens near Kolapilli, but on account of the more sandy stone, the reticulation of the veins is not so distinct as in the same species from the Rajmahal hills or from near Madras. But the identity is proved.

7. A fruit of a cycadeous plant belonging to the genus *Williamsonia*, Carr; it is pretty large, as in the Rajmahal series; in Kach we found some smaller specimens.

### IV.—*Coniferæ.*

1.—*Palissya pectinea*, Fstm. This quite characteristic coniferous species occurs pretty frequently.

2.—*Palissya Oldhami* also is represented in one specimen.

3.—*Echinostrobus* sp. Two specimens, somewhat indistinct, but from the ramification and disposition of the leaves they can be placed only in this genus; the species I have not yet determined.

4.—Scales of *coniferous plants* of a very large size, belonging most probably to ***Araucarites***, occur in some specimens.

This general view of the plants from Kolapilli exhibits at once some of the most frequent and most characteristic species from the Rajmahal series in the Rajmahal hills, so that we may safely take them to be on the same horizon and age.

*General table showing the relations of the now discussed series and their floras.*

| KACH (GENERALLY KACH SERIES) MIDDLE JURASS., EUROPE. | | RAJMAHAL SERIES (LOWER JURASS., EUROPE). | |
|---|---|---|---|
| Upper horizon. | Lower horizon (?) | Rajmahal Hills. | Kolapilli. |
| *Loharia;* not quite distinct. *Doodare, Bhoojooree, Kurbit;* these 3 with Oolitic forms, as enumerated above. *Oolite* (lower). | *Thrombow* with a *Palissya, like that from* the *Rajmahal series* and *Narbada* valley? *perhaps representing here the Rajmahal series. Near Gooneri,* containing the *Actinopteris*-like forms. | *Abundant* large *Tæniopteris, Pterophyllum; true Cycadites;* some *Otozamites, Palissya* (reminding? *Brauni,* Endl.) etc., offering a *liassic* view of the plants. Some *Alethopteris,* and a constant *Palissya* etc., *Lias* (of Austria ?); *common plant with* the *upper* horizon of Kach, *Ptilophyllum,* Morr.; with *Thrombow* the *Palissya* species, called by me Pal. *Oldhami* Fstm. | Containing abundant *Pterophyllum,* besides all the characteristic plants for the "Rajmahal series" of the Rajmahal hills (which must be taken as typical). *Liassic. Common* with *Thrombow,* the *Palissya* species called by me *Pal. Oldhami.* Fstm. With the *upper horizon* the coniferous scales (but much larger). |

There are two species of the genus *Ptilophyllum* Morr., common to both series; they are *Pt. cutchense* (prevailing in Kach) and *Pt. acutifolium,* Morr., prevailing in the Rajmahal series.

I would here give a list of the several works I have referred to bearing on our plant-bearing strata, their flora and age. We have Captain *Sherwill* (Journ. Asiat. Soc., 1851, p. 577,) on the Rajmahal hills, with a map.—Mr. *Th. Oldham* (in Journ. Asiat. Soc., Bengal, 1854, p. 263,) On the geology of the Rajmahal Hills.—*Th. Oldham* and *Morris,* "On the flora of Rajmahal series, Rajmahal hills," Palæont. Indica, 1862.—Mr. *Th. Oldham,* Mem. Geol. Survey of India, 1860, II Vol., "On the geolog. age of the rocks in Central India, Rajmahal hills, etc."—Captain *Grant,* "Geology of Kach." Transactions of the Geolog. Soc., Vol. I, sec. series, with description of the plants by Prof. Morris.—*Mc Clelland:* Report of the Geological Survey of India, 1848-49, with plates, Calcutta, 1850.—*W. T. Blanford,* Memoirs of the Geolog. Surv. of India, Vol. VI, "On the geology of a portion of Kach," p. 17.—Mr. *Wynne:* Mem., Geolog. Surv. of India, Vol. IX, "Geology of Kach".—Dr. *W. Waagen:* Records of the Geological Survey of India, "Abstracts of results of examination of the ammonite fauna of Kach," etc., Vol. IV, 1871, No. 4, p. 89.—Dr. *Waagen:* "Jurassic fauna of Kach," Palæontologia Indica, 1875.

*De Zigno:* Some observations on the flora of the Oolite: Quarterly Geolog. Journal, 1860, p. 110.—*De Zigno:* Sopra i deposite di piante fossili dell America settentrionale, *delle Inde* e dell Australia, etc., Padova, 1863.—*De Zigno:* Observations sur les Planches de l'Ouvrage de Mr. Oldham: "Sur les Plantes fossiles des Rajmahal hills" (manuscript, 1861, in our Library).—*De Zigno:* Flora fossilis formationis Oolithicae, Vol. I, 1856-68, pag. VI, etc.—*Bunbury:* General remarks and postcript in his Fossil plants of Nagpur: Quarterly Journal Geolog. Soc., XVII, (1861), p. 34, f. f.—*Hislop:* "Nagpur Sandstone" etc.: Quarterly Journal, Geolog. Soc. XVII, (1861), p. 349. Rajmahal Hills.—*W. Haidinger:* Verhandlungen der k. k. Geolog. Reichsanstalt, Wien: Pflanzenfossilien aus den Rajmahal Hügln, 1861-62, Bericht. vom. 31 Juli, p. 80.

I may also mention some works in which special mention is made of our fossils. There is Mr. Schenk's "Flora der Grenzschichten zwischen Keuper und Lias", 1867, where especially the systematical position of some of our Rajmahal species is discussed, and where *Equisetum Rajmahalense,* Oldh., is considered as a liassic form. Mr. *Ettingshausen,* in his "Die Farrenkräuter der Jetztwelt" 1865, mentions especially the *Tæniopteris lata,* Oldh., *Tæniopt.,* Morris, Oldh., placing it with the living *Acrostichum* (which, however, is of no use in the question of the age); as to the localities he states: "In formatione *Lias* dicta ad *Bindrabun* Bengaliæ."

Mr. *Saporta*, in his "Végétaux fossiles du Terrain jurassique," in the Paléontologie Française, 1872-1875 (Nos. 1-18), mentions in several places our fossil plants from the Rajmahal hills. Of Mr. *Schimper's* Paléontologie Végétale, 1867-1874, I have already said what was necessary, and repeat only that our Rajmahal fossils, and also those of the Damuda, must be eliminated from his list of the fossil plants of the Oolitic period, and be put in their proper places.

In 1875 we have again a note by Mr. *Zigno* on the Rajmahal Flora in Verhandl. d. k. k. geolog. Reichsanst. No. 17, where he again approves the Liassic age of the Rajmahal Flora.

I must finally mention a paper by Mr. *H. F. Blanford*, published in the Quarterly Journal, Geolog. Society, 1875, November, with the title, "On the age and correlations of the plant-bearing series of India, and the former existence of an Indo-Oceanic Continent", in which, however, regarding the flora all is repeated from the former publications of the Survey, and therefore requires the same corrections. I will only mention that all the lists of fossil plants given by Mr. Oldham were only provisional; and that many of the genera were subsequently determined to be different; which, of course, also changed the conclusions to be made from them.

It is thus obvious that I do not agree in identifying the horizon of the Kach with that of the Rajmahal series in the Rajmahal hills, on the Godavari and near Madras. Nor is it at all probable that the Damuda series are Permian; as the *Schizoneura*, which is so very frequent in the upper Damudas, is not known anywhere in Permian strata, but in Trias. I may also mention the recent discovery in the Barakar group of a *Voltzia* and of a very distinct single-pinnate *Neuropteris*, Bgt., which till now is nowhere known in the Palæozoic (*viz.*, Permian) strata, but only in the Triassic (*viz.*, Buntsandstein—grès bigarré) rocks*; proving, besides other evidence, that the lower Damudas also are of mesozoic age, as I will show more fully in a later paper. From these facts one will be also able to make further conclusions on the age of the Australian plants, as being identical with our Damuda plants.

## Description of a cranium of Stegodon ganesa, with notes on the sub-genus and allied forms, *by* R. Lydekker, B. A. (Cantab), *Geological Survey of India.*

The cranium described in the present paper is a remarkably fine and nearly perfect specimen belonging to *Stegodon ganesa* (Falconer). It was discovered by Mr. Theobald in the grey sandstone beds of Maili, belonging to the middle Siwalik series. In describing this specimen I have of necessity been led to examine the other allied species, and in the present paper intend giving a few notes on the sub-genus.

The sub-genus or genus (?) *Stegodon* as originally founded by the late Dr. Falconer, comprised four species, *viz.*, *S. insignis*, *S. bombifrons*, and *S. ganesa*, from the Siwaliks, and *S. cliftii*, from the tertiary beds of the Irawadi: subsequently, Professor Owen (Q. Jour., Geol. Soc., Lon., 1870, p. 417) added two other species to this list, *viz.*, *S. orientalis* and *S. sinensis*, founded on fragments of molar teeth brought from China. In spite of the reputation of the founder of these last two species, I cannot help doubting their validity as being based on the characters of the teeth alone, as these are so very similar in all the species; at the same time, I should be by no means surprised that, if at any time the crania of the Chinese species should be discovered, it (or they) would be found to differ from the Indian species.

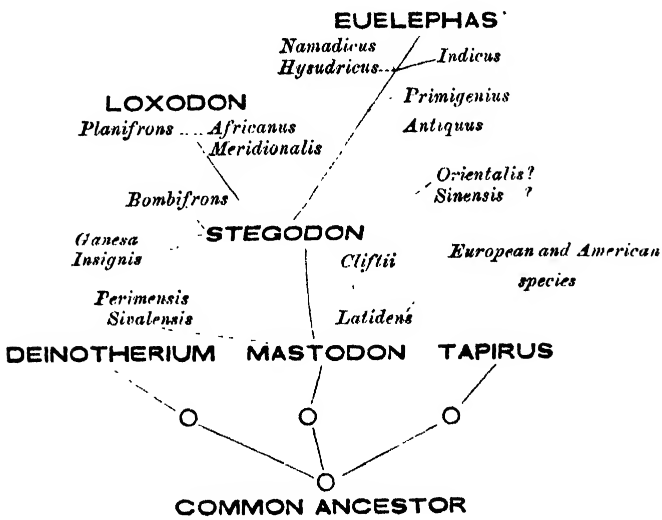
* Schimper and Mougeot: Monographie des plantes fossiles du grès bigarré des Vosges, 1847, 40 plates.

I therefore consider the molars of *Stegodon ganesa* and *Stegodon insignis* as indistinguishable one from the other; the skulls are, however, easily recognized, that of *S. insignis* "being singularly modified, so as to bear an analogy to the cranium of *Deinotherium*, while the head of *S. ganesa* does not differ much from the ordinary type of the elephant" (Pal. Mem., vol. I, p. 81). In spite, however, of this striking difference in the two crania, Dr. Falconer, subsequently to writing the above passage, had reason to doubt the specific distinctness of *S. ganesa*: he did not state, however, on what grounds, or with which species he proposed to amalgamate it; the distinctness, however, of the molars of *Stegodon bombifrons* shows that it must have been with *S. insignis*. If any certain distinction could be drawn between the molars of *S. insignis* and *S. ganesa*, it would be of itself sufficient to confirm the distinctness of the latter; as it is, we are driven to depend on the character of the crania alone.

At first sight the huge tusks and alveoli, the large size of the inter-alveolar fossa and of the nasal fossa, together with the high and vaulted frontals, appear alone quite sufficient to distinguish the cranium of *S. ganesa* from the small-tusked *S. insignis*, with the small nasal fossa, and the peculiar flattening and ridging of the frontals; if, however, we turn to the figures of the crania of *S. insignis* in the "Fauna Antiqua Sivalensis," we shall find that the peculiar shape of the frontals of the adult of *S. insignis* is not present in those of the young animal: (the peculiarity in the adult arising from a partial development of the intertabular fossæ). From this fact, in accordance with Falconer's doubts, I have thought it might be possible that *S. ganesa* is only a huge-tusked male form, of which *S. insignis* is the female; in the former, in correlation with the great development of the lower part of the skull to carry the large tusks, the frontal sinuses are also developed in like manner, and not aborted as in the female *(S. insignis)*.

The size of the crania of *S. ganesa* in the British Museum is, however, much larger in proportion to those of *S. insignis* than occurs in the living species of elephants; and I cannot but think it expedient to continue to consider the two as distinct species, as the crania are so widely different. The present cranium has smaller tusks than any described specimen of *S. ganesa*, although they are still much larger than those of *S. insignis*. I think it, therefore, not improbable that this may be a female form, which supposition would at once do away with the above hypothesis; there appears to be a difference in the number of cusps in the molars of this specimen from typical forms, which, according to Prof. Owen, might be grounds for specific distinction.

Apparently, from the specimens in Falconer's collections in the typical Siwalik strata of the districts adjoining the Jamna, which include the highest beds of the series, the skulls and molars of the highly specialized sub-genus *Euelephas*, as exemplified by *E. hysudricus*, were equally common with either of the species of *Stegodon*; passing, however, more to the westward, towards the Satlej and the Beas districts, we find that most of the fossils obtained by Mr. Theobald (which form the chief part of the Siwalik collection of the Geological Survey) are obtained either from the middle grey sandstones, or the lower red clays,—both older than the Markanda river beds; among these fossils the proportionate number of *Stegodon* molars to those of *Euelephas* is about 30 to 1; or in the proportion of 10 to 1 (allowing for the three species of *Stegodon*). In the newer deposits of the Narbada valley, we find *Euelephas Namadicus* the dominant species, while *Stegodon* is only represented by a few specimens of *S. insignis*; in the present Indian Fauna, *Euelephas* alone survives, *Stegodon* having died out; the latter genus is confined to the tertiary beds of India, Burma and China; we find, therefore, as might have been predicated on anatomical grounds, that the simple form, *Stegodon*, appears to have been gradually dying out since Siwalik times (how long before that it originated we are unable at present to say), and to have been replaced by the more highly specialized forms of *Loxodon* and *Euelephas*, of which the latter is the most highly specialized. The pedigree of the *Proboscidia* is probably something of this sort, as shown in the diagram; *Tapirus* connecting it with other *Ungulata*.




Until geological explorations have been carried out to a greater extent in the countries between India and England, it is impossible to say in which direction the migration of elephants took place; it would not, however, be unreasonable, from the number of species and genera found in the Siwaliks and other Indian strata, to suggest that India was the original home of the family (*Elephas, Mastodon, Deinotherium*, and *Tapirus* are all found fossil in India), and that the migration took place from thence, all the sub-genera having taken origin in that country, probably long before Siwalik times; thus *Loxodon planifrons*, or an unknown allied species, might have travelled westward and given rise to *Loxodon meridionalis* of the English "Forest Beds," and subsequently to the living *Loxodon africanus*. In the same way, *Euelephas* may first have given rise to the Siwalik species, from which again sprung the Narbada species and the living *Euelephas indicus*, and on the other hand, to another branch which travelled over Asiatic Russia, and thence to Europe, producing the Mammoth *E. primigenius* and the other European species.

*Mastodon*, as having the widest distribution—Europe, Asia, and America—as well as from being the most generalized type of the family, may well be considered as the most ancient form of the group; its earliest occurrence in India is in the supra-nummulitic beds of Sind and Kach, and its latest existence was probably in the marshes of the Ohio, where it not unlikely lived down to the human period; it is the only American representative of the family, and its migration may well have taken place from India westward to America. *Mastodon* was the first of the elephants to die out in India, it being unknown after the Siwalik period.

The present specimen of *Stegodon ganesa* exhibits the whole of the cranium in very perfect and complete condition; the chief injuries are the absence of the zygomatic arches, which have been broken off close to their respective origins; and the absence of the greater portions of the tusks, the incisive sheaths having been broken off near their base; the bones composing the wall of the left temporal fossa have been much crushed and comminuted, but have been subsequently roughly recemented together by a calcareous infiltration.

In its original state the cranium was almost completely embedded in a mass of the common Siwalik grey sandstone, which, though generally soft, became almost as hard as granite as it approached the bone. The mass of stone in which the specimen was embedded was, as is so commonly the case with Siwalik fossils, a detached boulder, which had undergone a considerable amount of rolling and weathering: the fractured extremities of the tusks had evidently been exposed for a considerable time to the action of the weather, being much decomposed, and easily separating into a series of concentric rings. The bone had lost its animal matter, adhering very strongly to the tongue, and absorbing a great quantity of the glue with which it was treated.

The general outline of the facial and frontal portions of the cranium correspond nearly with that of Colonel Baker's large cranium of this species in the British Museum; this is noticeable in the comparatively large size of the incisive sheaths, the large and deep fossa between them, and in the continuity of the fronto-incisive planes; when examined in detail, however, certain smaller points of difference exhibit themselves.

The frontal plane of Colonel Baker's specimen of this species is remarkable for its broad and smooth expanse, scarcely roughened by any ridge or protuberance; in this specimen a bold rounded ridge is continued upwards and backwards along the mesial line of the frontals from the nasals, and terminates in a rounded boss, some eight inches above the naso-frontal suture; on either side of this ridge there is a marked depression, broadest above the nasals, and gradually narrowing as it passes upwards: externally to this depression a sharp trihedral ridge is continued upwards from the post-orbital process of the frontal, imperceptibly losing itself in the flat surface of the parietals. There is no resemblance to the flattened upper frontals and supra-nasal ridge of the cranium of *Stegodon insignis*.

The large dimensions of the nasal bones (see table of measurements) differ from those of typical specimens of the species, and still more widely from those of all other species, especially *S. insignis*, in which they are remarkably small; they are more than double the size of the corresponding bones in Colonel Baker's cranium, and four times that of the nasals of *S. insignis*. The nasals form a downward prolongation of the mesial frontal ridge; they are of great thickness, being composed of a mass of finely cancellated bony tissue, project far over the nasal fossa, and have a somewhat quadrate free termination. The lower border of the frontals, forming the upper boundary of the nasal fossa, sweeps upwards in a bold arch on either side of the nasals: in Colonel Baker's cranium this line of the frontals is much straighter and is scarcely interrupted by the small nasals. The lower border of the nasal fossa slopes away evenly from either side to the median line; at this line a deep triangular notch, on either side of which are the posterior processes of the premaxillæ, connects the nasal and incisive fossæ; below this notch the incisive fossa becomes suddenly very deep; in Colonel Baker's cranium the inter-premaxillary notch is much shallower, and the processes blunter: in *S. insignis* the notch is almost absent, and the incisive fossa becomes gradually, not suddenly, deep.

The incisive fossa is of great size and depth, its outer walls are nearly perpendicular to the base, and parallel to each other; in Colonel Baker's cranium the inner walls of the incisive sheaths are curved, the concavity looking inwards: in *S. insignis* the incisive sheaths are very slender and diverge rapidly outwards, in a manner very different from either of the above.

In a side view of the cranium, the upper boundary of the large temporal fossa is of an elongated ear-shape, just as in Colonel Baker's specimen; the cranial wall of this fossa runs in a plane nearly at right angles to the roof of the cranium, as far down as a line connecting the post-orbital process of the frontal with the lower border of the posterior zygomatic root; along the line of the nervous foramina, there is an abrupt fall inwards from this vertical plane, to join the plane of the molar alveolus. In Colonel Baker's specimen the wall of the temporal fossa begins to curve inwards very rapidly, which curve is continued without any break at the nervous foramina, to join the plane of the molar alveolus. In *Stegodon insignis* the temporal fossa is curved antero-posteriorly, as well as from above downwards, differing very markedly from either of the above forms.

The walls of the temporal fossa, in this and in all other specimens of *Stegodon ganesa* that I have seen, are straight antero-posteriorly, and are placed nearly at right angles to the plane of the face; there is never any wedge-shaped indentation of the fossa towards the median line in the middle of the frontals, which renders the greater part of the walls of the fossa visible from the front of the skull, as always occurs in the crania of *Stegodon insignis*, and which gives it its characteristic form.

In the crania of all other elephants that I have seen, the course of the optic nerve, after emerging from its foramen, is continued outwards across the orbit, in a deep channel, which grooves the inferior surface of the post-orbital process of the frontal; in the present specimen this channel is absent, the surface of the bone being perfectly smooth; this feature is probably only an individual variety.

In a front view of the cranium, as stated above, only a very small portion of the temporal fossa of either side comes into the field of view; the external outline of the lower portion of the cranium differs in several respects from Colonel Baker's specimen, probably owing to the smaller size of the tusks. The anterior zygomatic root stands out from the outer border of the incisive sheath almost at a right angle, throwing the infra-orbital foramen entirely out of the line of the incisive fossa, while the foramen itself looks nearly directly forwards. In Colonel Baker's specimen the anterior zygomatic root slopes away very gradually from the outer wall of the incisive sheath at an obtuse angle of nearly 120°, the infra-orbital foramen occupies a notch in the outer border of the incisive sheath, and looks considerably outwards as well as forwards. The position and form of the anterior zygomatic root and foramen in the present specimen resemble the position of the corresponding portions in the cranium of *Stegodon insignis*, and might, therefore, be taken as evidence for the specific identity of the two forms: I rather regard this position, however, as due only to the smaller size of the tusks; while the greater size of the present cranium, and the form of the frontals and temporal fossæ, serve to show that a smaller tusked form of *Stegodon ganesa* exists, without making any approach in the form of the upper cranium to the cranium of *Stegodon insignis*, so peculiarly modified in the upper regions.

The occipital surface is much flattened, having an irregular hexagonal outline, of which the parietals form the longer superior border, and the condyles the shorter inferior border; on its outer side, this surface slopes away rapidly to form the posterior boundary of the temporal fossa; the hollow for the insertion of the ligamentum nuchæ commences about five inches above the foramen magnum, and is continued vertically upwards for a distance of eleven inches, averaging an inch and a half in width, and rather less in depth.

The following measurements of this cranium are compared below with those of Colonel Baker's specimen, figured in plate XXI of the Fauna Antiqua Sivalensis, and described at page 33 of the description of the plates to the above:—

| Measurement in inches of crania. | Present specimen. | Col. Baker's *S. ganesa.* |
|---|---|---|
| Width of incisives at infra-orbital foramen ... ... ... | 6·5 | 7·5 |
| Width of ditto below ditto ... ... ... | 6·5 | 10·75 |
| Length of cranium from occipital condyles to anterior border of molar alveolus ... ... ... ... .. ... | 25·0 | 25·0 |
| Vertical height from condyles to sinciput ... ... ... ... | 25·0 | 24·0 |
| Lateral diameter across occipital condyles ... ... ... | 9·0 | 9·2 |
| Antero-posterior diameter of left condyle ... ... ... ... | 5·0 | 5·0 |
| Transverse diameter of ditto ... ... ... ... | 4·0 | 3·85 |
| Ditto ditto of foramen magnum ... ... ... ... | 3·0 | 3·0 |
| Antero-posterior diameter ditto ... ... ... ... | 2·9 | 3·1 |
| Diameter of widest part of supra-occipital ... ... ... | 28·0 | 20·2 |
| Ditto naso- præmaxillary fossa ... ... ... ... | 16·0 | 16·0 |
| Interval between nasal fossa and post-orbital margin of frontal ... ... | 4·3 | 4·55 |
| Extreme width of frontals ... ... ... ... ... | 27·5 | 26·25 |
| Length of incisive (broken in specimen) ... ... ... ... | 21·0 | 31·0 |
| Depth of zygomatic fossa ... ... ... ... ... | 4·5 | 4·25 |
| Estimated width of cranium between centre of temporal fossa ... ... | 17·0 | 19·25 |
| Height from lower margin of meatus auditorius externus to sinciput ... | 20·0 | 18·0 |
| Ditto posterior margin of molar alveolus to sinciput ... .. | 30·0 | 32·0 |
| Length from upper border of foramen magnum to posterior margin of molar alveolus ... ... ... ... . ... | 9·0 | 9·5 |
| Vertical height of orbit ... ... ... ... ... | 8·9 | 3·78 |
| Transverse diameter of middle of left incisive sheath ... ... | 8·0 | 11·5 |
| Vertical diameter of left incisive sheath ... ... ... ... | 7·8 | 10·6 |
| Ditto of infra-orbital foramen ... ... ... | 3·7 | 3·85 |
| Transverse ditto ditto ... ... ... | 1·5 | ...... |
| Interval between distal ends of second molar ... ... ... | 4 0 | 2·7 |
| *Interval between proximal ditto ditto* ... ... ... | *5·2* | *3·25* |
| *Length of right second molar* ... ... ... ... | *16·0* | *11·9* |
| *Width of ditto ditto ditto at second ridge* ... ... .. | *4·3* | *4·05* |
| *Ditto ditto ditto ditto at penultimate ditto* ... ... | *5·5* | *5·0* |
| Vertical height from posterior extremity of outer border of second molar alveolus to post-orbital process of frontal ... ... ... | 21·5 | 21·0 |
| Distance between outer surfaces of second molars at fifth ridge ... ... | 13·5 | 12·6 |
| Antero-posterior diameter of meatus auditorius externus ... ... | 1·2 | 1·15 |
| Transverse ditto ditto ... ... ... ... | 1·0 | 1·0 |
| Length from upper border of foramen magnum to tip of nasals ... ... | 55·0 | ...... |
| From tip of nasals to præmaxillary protuberance ... ... ... | 7·0 | ...... |
| Height from lower border of anterior zygomatic root to crown-surface of second molar ... ... ... ... ... ... | 25·0 | ...... |
| Width of nasals at base ... ... ... ... ... | 5·5 | 3·0 |
| Length of ditto ... ... ... ... ... ... | 3·8 | 1·6 |
| Long diameter of posterior nares ... ... ... ... | 6·0 | ...... |
| Transverse ditto ditto ... ... ... ... | 3·0 | ...... |

From the above table of measurements we find the general measurements of the two crania not varying more than might be expected in two different individuals; but the respective dimensions of the tusks and their alveoli are very different. Thus it will be seen that, in the present specimen, the transverse diameter of the incisive sheath above and below the infra-orbital foramen is the same; while in Colonel Baker's cranium the sheaths are constricted at the foramen, and suddenly expand below this point. The transverse diameters of the incisive sheaths of the two crania below the infra-orbital foramina are in the proportion of 8 to 11·5, and the antero-posterior diameters in the proportion of 7 to 10. The circumferences of the respective incisive sheaths are 20 and 30 inches; the length of the tusks of Colonel Baker's specimen, from the distal extremity of the incisive sheath to their tip, is 9 feet 8 inches; if the length of the tusks in the present specimen bears the same proportion to their diameter, as it does in Colonel Baker's specimen, this would not have exceeded 6 feet 9 inches, making a difference of 2 feet 9 inches in the length of the tusks in the two individuals; very probably the difference may have been still greater.

The next most noticeable difference in the measurements of the two skulls occurs in the palate; the palate of the present specimen is wider than that of Colonel Baker's specimen, in the proportion of 4 to 2·7 at one end and 5·2 to 3·2 at the other. The nasals of the present specimen are nearly twice as large as those of Colonel Baker's specimen; the transverse measurements being 5·5 and 3·0, and the antero-posterior measurements 3·8 and 1·6 inches.

The vertical height of the present specimen is one inch greater than that of Colonel Baker's specimen; and the width of the frontals is 1¼ inch greater.

If now we turn to the figures of the crania of *Stegodon insignis* given in plates 16 and 17 of the "Fauna Antiqua Sivalensis" with their accompanying measurements, we find that the specimen figured in plate 17, fig. 1, has a diameter of only 25·5 inches across the occiput, 3 inches less than in the present specimen; while its vertical height is 4·5 inches less; the whole cranium, in fact, being greatly smaller than the present, and differing by the peculiar form of the forehead so greatly as to have very little general resemblance.

From the above facts I conclude that the present specimen proves the existence of a small-tusked variety of *Stegodon ganesa*, of which the cranium is at least as large as in the big-tusked variety, and which, moreover, shows no approach to the peculiarly modified cranium of *Stegodon insignis*, of which the tusks are still smaller; the present specimen might well be a female of *Stegodon ganesa*, while *Stegodon insignis* will still stand as a distinct, though closely-allied, smaller species (in the modern acceptation of the term) distinguished by its peculiar frontals and temporal fossæ; the teeth of the two species being indistinguishable from each, and indicating a very close affinity.

Continuing our description of the present specimen, we find that two pairs of molars are protruded from their alveoli; the first pair have been in wear for a considerable period, and are much worn away in front, the number of ridges remaining being only seven. In the second molar of the left side, eight ridges may be counted, together with an anterior talon ridge: between the first and second ridge there is a small conical tubercle on the outer side. This molar is only partially protruded from its alveolus; from the width of the last visible ridge, there must be two or three more ridges still concealed in the alveolus: this would make the tooth the last of the permanent molar series, in which the number of ridges should be either ten or eleven; the penultimate molar never has more than eight ridges; the fact of this tooth being the last of the series proves the animal to have been fully adult, and that the tusks had attained their full size and development.

The unworn ridges on the last molar are remarkably clear and sharp, displaying in great perfection the cusps on their summits; as in the typical specimen, they have the usual transverse bowed form, with clean transverse valleys, without any trace of a median, fore-and-aft cleft; the outer side of the worn ridges is lower than the inner side.

The first ridge of the ultimate molar is unusually thick and massive; it has an imperfectly-divided talon on its anterior side: its longer or transverse diameter is 4 inches, and the shorter or antero-posterior diameter 2 inches; the interval between the summits of the second and third ridges is 1·2 inches, and that between the seventh and eighth ridges 1·6 inches. The depth of the valley between the sixth and seventh ridges is 1·5 inches; transverse diameter of the fifth ridge is 4·2 inches. On the fifth ridge there are no less than thirteen sharply-pointed cusps visible: the sixth cusp, counting from the inner side, on this, and the immediately adjacent ridges is somewhat larger than the rest, and its hollow on the outer side somewhat deeper. This sixth cusp and valley will probably indicate the line homologous with the medial fissure of the molars of *Mastodon.*

The great number of cusps on the ridges of the last molar is an unusual character among the Siwalik *Stegodons*; a character to which, however, as stated above, I do not attach much value: the thirteen cusps on the fifth ridge do not probably represent the total number, as the whole of the ridge is not protruded from its alveolus; there are, no doubt, at least two still concealed; this would bring up the whole number to fifteen.

The greatest number of cusps contained in a single ridge of any of the molars of *Stegodon ganesa* figured in the "Fauna Antiqua Sivalensis" is eight; in *S. insignis* ten; and in *S. bombifrons* nine. In *Stegodon orientalis*, Prof. Owen says, the cusps are "about a dozen in number"; and in *S. sinensis* he infers them to be twelve or thirteen. If the number of cusps be any criterion of specific identity, as Prof. Owen thinks it is, the present cranium would belong to a fifth Siwalik species, which would be most nearly related to the Chinese species. The close resemblance of the cranium, however, to the typical *Stegodon ganesa* at once forbids this supposition; and I should be therefore inclined to doubt the validity of Prof. Owen's new species, founded mainly on this character.

As an instance of the variability of this character, I may cite a specimen of a right mandible of *S. insignis* in the collection of the Imperial Museum (No. 63 S.); the specimen contains the third milk-molar just protruded from its alveolus; this tooth shows seven ridges; the fifth of these carries eleven cusps, a greater number than I have seen on even a last molar of this species. I think, therefore, that this character, as of specific value, must be abandoned; if so, Prof. Owen's Chinese specimens must also be abandoned, as they are founded chiefly on this character and some slight variation in the enamel.

## NOTE UPON THE SUB-HIMALAYAN SERIES IN THE JAMU (JUMMOO) HILLS, BY H. B. MEDLICOTT, M. A., *Geological Survey of India.*

The 'Jamu Hills' may conveniently be taken to designate the several ranges, of steadily decreasing elevation, between the flanks of the Pir Panjál and the plains of the Panjáb, from the Rávi to the Jhelam. At the Rávi they are the direct continuation of the ranges in the Kángra district. For many years this ground has been a missing link in our study of the great Sub-Himalayan series of tertiary rocks. So long as those territories could boast of a geologist of their own, we refrained from trespassing upon his rights; but soon after the departure of Mr. Drew, steps were taken towards closing this gap in our wor . Every facility has been granted to us by His Highness the Maharajah and his ministers.

The special point to be cleared up was, the discrepancy between the sections of these rocks as described by me in 1862 (Mem. Geol. Surv., Ind., Vol. III) in the region of the Ganges and the Satlej, and those observed by Mr. Wynne in the country west of the Jhelam. I had made out two very marked breaks in the series. One was where the topmost beds of the great mammaliferous deposits rested against and upon an inner belt of older rocks. As the former were conspicuously the home of the famous Siwalik fossils, I restricted this name to that younger group of rocks, giving the name of Náhan to the older beds upon which they rested unconformably. It was certainly rash of me thus to tamper with a well-known name. Although the fauna of the Náhan rocks is still unknown to us, it presumably will include mammalian remains, having more or less of affinity to those known as Siwalik; and it may be palæontologically desirable to make the same name cover all. This, of course, can still be done, if required, substituting some local name in the application I gave to Siwalik.

The second break in the eastern section occurs where the Náhan rocks abut against the old slaty rocks of the higher mountains, high upon which there rests an extensive remnant of still older tertiary deposits, including at their base the nummulitic beds of Subáthu, transitionally overlaid by red clays and grey sandstones in distinguishable zones, to which I gave the names Dagshai and Kasáoli. I subsequently denoted these three older bands collectively as the Sirmúr group, it being desirable to restrict the name Subáthu to the nummulitic zone proper. There was little direct evidence as to how far the boundary between the Náhan and Sirmúr groups might also be an aboriginal unconformity, or altogether due to flexure and faulting; but the fact that in the lowest outcrops of the Náhan band over a very large area no symptom could be detected of the very characteristic Subáthu zone, nor any specific representative of the Kasáoli beds, which in the contiguous area are repeatedly marked by peculiar plant layers, gave strong presumptive evidence for the supposition of aboriginal unconformity.

No trace of these very marked stratigraphical features of the Simla region could be detected by Mr. Wynne in the country west of the Jhelam; although several of the zones could be identified with great certainty. The Subáthu nummulitics are very characteristically represented west of Mari (Murree), and over them, at Mari itself, the rocks exactly resemble the Dagshai beds; while at the upper end of the series the Siwaliks are in great force, with their characteristic fossils.

As an unknown quantity between these two contrasting sections there was the remarkable fact that the axes of flexure in the rocks west of the Jhelam have a direction at right angles to that of the contiguous Himalayan ranges; the change taking place abruptly along the course of the river. It is the junction or confluence, the knee, as it has been termed, between the lines of the Himalaya proper and those of the Hindú Kush. There seemed a possibility that the total disappearance westward of the boundaries so strongly marked at the base of the Himalaya east of the Satlej might be closely connected with this striking transverse feature of the mountain structure. Such, however, is not the case. These two systems of flexure are continuous and cotemporaneous.

The difficulty of establishing divisions in the immense series of tertiary strata which has so hampered Mr. Wynne in his examination of the trans-Jhelam country, had already strongly declared itself to me in the hills between the Satlej and the Rávi. On the map published with my memoir, it will be seen that the Náhan-Siwalik boundary and the Náhan zone itself is stopped abruptly and arbitrarily at the Satlej. I found that the abutting, overlapping junction of topmost Siwaliks against low Náhans had gradually changed into vertical parallelism; the ridge of Náhan rocks here taking the form of an anticlinal, sinking to the north-west, round the point of which the Siwaliks turn over into the inner valley. Finding that the several broad dúns (flat longitudinal valleys) of the Kángra district were occupied by rocks of Siwalik type, and not having time to work out their approximate separation from the core of Náhan beds in some of the dividing ridges, I coloured the whole area as Siwalik, giving due notice of this on the map itself and in the descriptive text. Thus already in the Kángra district the Náhan-Siwalik boundary was extremely difficult to fix.

The other great boundary-feature of the Simla region, that between the Náhan and Sirmúr groups, also undergoes much change immediately west of the Satlej; and in a similar manner to that described for the Náhan zone; the whole Sirmúr group becomes lowered along the strike to the north-west, so that the Subáthu zone is altogether suppressed. On this account, and because this structure would probably bring in higher beds, the north-western extension of the Sirmúr band was coloured as Náhan in my map of 1862. It is for this zone the beginning of the compromise that must be adopted to reconcile the different distribution of the strata in the separate sections of the mountain region. The actual boundary of this innermost tertiary zone is still as clear as ever, because there is a corresponding change in the outer contact rocks; Siwalik conglomerates abutting against it all along the Kángra Dun.

There is still a leading feature of contrast between the two regions separated by the Jamu hills. In the Simla region the Subáthu beds rest on a deeply denuded surface of the next oldest strata, supposed to be of lower secondary age; whereas beyond the Jhelam no such unconformity has been observed. This, it is evident, is a difference of precisely the same character as those already noticed within the tertiary series; and it is very noteworthy that these changes coincide in position with the most remarkable bend in contour of the boundary of the higher mountains, formed of old rocks, where for a length of nearly eighty miles it runs north and south, making an angle of 45° with the general course of the range. The direct continuity of the outermost base of the hills bounding the plains is maintained, past this bend of the higher mountains, by a greatly increased width of the fringing belt of the tertiary rocks.

These leading features of the two regions, as partially sketched in the preceding paragraphs, have been for some time more or less fixed; and the interpretation I have put upon them is simply that the disturbances marking the Himalayan system, *as displayed in the centre of its area,* are of earlier date than those affecting the terminal portion and the Hindú Kush; that in early or middle secondary times a general elevation occurred of the south Himalayan area, along the border of which the Sirmúr deposits subsequently took place; that the eocene period was closed by the more special disturbance with crushing which constituted, perhaps, the principal phase of the mountain formation; that after a period of denudation the Náhan deposits set in; that a similar interruption produced the break between the Náhan and Siwalik groups; while during all that time little or no elevation took place in the region of the Jhelam. Our observations in the Jamu hills have not disturbed these conjectures.

During the past cold season I had the advantage of going over part of my old ground, from the Satlej to the Rávi, through the Jamu country, and over a part of the trans-Jhelam districts, in company with Mr. Theobald and Mr. Lydekher. The snow prevented us following the innermost tertiary boundary along the flanks of the Pír west of the Chenáb; but this was not our principal object, and Mr. Lydekher is now engaged in examining that ground. We satisfied ourselves that on the Satlej there is no assignable break, faulted or otherwise, in the sequence from the Náhan to the Siwalik strata, although a very approximate position (that given in my map) can be made out for the change from the harder, deeper-coloured clays and sandstones of the former, to the paler or brighter and softer rocks of the fossiliferous upper group. This distinction is more or less discernible throughout the whole range to the north-west. It may be very well seen on both sides of the Bakrála ridge between Jhelam and Ráwalpindi.

As might be expected from its much greater magnitude, the middle tertiary break—that appearing in the Cis-Satlej region as a Náhan-Sirmúr contact, and in the Kángra district marked on my map as a Siwalik-Náhan boundary—is clearly defined for a much greater distance westward than the Náhan-Siwalik break of the Simla region. On the Rávi, as all through the Kángra district, the Siwalik conglomerates are in great force along it; but west of the river an oblique strike brings in lower beds, which are less distinguishable; still, the feature as a structural break is easily followed to near Udampúr, where the fault dies out in the irregular flexures of the region of the Choti-Táwi. Here one must trust to aboriginal characters of the strata in any attempt to separate the lower as well as the upper zones of tertiary rocks.

In examining the extension of the inner belt of tertiaries this year, I hit upon two outcrops bearing on this point. Where this zone runs north and south along the left bank of the Rávi, under the point of the Dháoladhár ridge, it is very much compressed, being not more than a quarter to half a mile in width. In this very crushed, probably inverted, outcrop I found a characteristic sample of the Kasáoli plant bed, the only occurrence of it known west of the Satlej. Should the unconformity between the Kasáoli and Náhan horizons in the eastern region be confirmed, this observation will extend the separation of the zones up to the Rávi; and I shall have been over-cautious in introducing the Náhan strata in this position so far to the eastward on my map.

Where the Rávi leaves its mountain gorge and turns sharply to the south, there is also an acute bend in the strike of the bottom tertiary zone, and from here to the westward this band increases steadily in width, chiefly owing to the gradual retreat of its inner boundary, which crosses the high ridge into the Chenáb valley north of Chinéni. The breadth here at fifty miles from the Rávi is over twelve miles. In the valley of the Pine over the village of Marún, fifteen miles from the Rávi, I got a small outcrop of earthy nummulitic limestone, the first identification of the Subáthu zone west of the Beas. This case illustrates well the difficulty of fixing the bottom division of the tertiary series—the Subáthu-Dagshai boundary, if the Sirmúr group maintains its distinctness so far; or the Subáthu-Náhan boundary, if the Upper Sirmúr group merges into the Náhan group, as seems certainly to occur at some part between the Rávi and the Jhelam. This nummulitic outcrop on the Pine, in the midst of a great section of bright red clays and pale-greenish sandy beds near the south boundary of the Sirmúr band, is about the highest position in which I have found nummulitics; and it exhibits again how closely the great supra-nummulitic red deposits are connected with that formation in the Himalayan region.

I may here note an important observation I made this year regarding the inner boundary of this oldest tertiary zone. In the position already noticed along the west base of the Dháoladhár where the recognisable band of these rocks is so narrow, being compressed, crushed, and apparently inverted, there is no definable boundary between them and the contiguous rocks of the mountain which here consist of a broken amorphous mass in a semi-metamorphic trappoid condition, red and green vesicular and quasi-amygdaloidal *pseudo-trap* being the prevailing type. The amygdala are not the smooth vesicles produced by elastic fluids in a fused rock; they are of irregular shape, but are quite filled with infiltrated minerals. There is a magnificent fan of the débris of this crumbling mass just below Simliu, and now deeply cut into on the left bank of the Rávi. I could not but conclude that this peculiar rock is a metamorphosed condition, through enormous pressure, of the Subáthu nummulitics. Now it exactly resembles the so-called trap of the Pír Panjál and Káshmír, the débris of which is the most abundant shingle in the torrents from that range, and of the age or origin of which there is no definite knowledge. If the observation here recorded can be extended to that region, an important step will be made towards understanding its intricate geology.

As the inner tertiary zone expands to the west of the Rávi, the enormous thickness of the supra-nummulitic groups has room to display itself. The cross-gorge of the Choti-Táwi is a line of depression, the rocks of the high ridge to the north-west of it having a steady south-easterly dip. Strata much higher in the series occur here. There are thick masses of pale soft clays north of Chinéni that may even be Siwalik. Indeed, here for the first time in this zone, which in the east, as has been said, is lifted bodily upon a pedestal of the old slates, we find, as is so general in the outer tertiary zones, conglomerates along the inner boundary of the area and forming the top of the series. At several places in the upper Táwi valley, below the Bindi gap, coarse and massive conglomerates are at the contact nearly vertical. These are most important, as bearing upon the question of sub-division of this Sub-Himalayan tertiary series: do these beds represent the Siwalik conglomerates? If not, we can scarcely avoid the inference that there are concealed unconformities to be looked for. The search for fossils is the most hopeful way of settling the point; but as I was traversing the country by forced marches to pick up the leading structural features of a large area, I could not stop for this purpose. The internal evidence of the beds themselves is, however, very significant: the imperfectly rounded shingle, some blocks as large as 2 feet in diameter, is almost exclusively made up of the bottom tertiary sandstone. The identification is certain. A fact of this nature was one of the confirmatory points for the Náhan-Siwalik unconformity in the Simla region, the source of these boulders being there evident; whereas for the conglomerates on the Táwi there is no apparent source; every trace, so far as is known, of the tertiary rocks having been removed from the region to the north. The fact is, however, absolute as to their once having extended in that direction, and as to their disturbance and denudation before the deposition of this conglomerate, certainly suggesting possible unconformity here, and in favour of the conjecture, that these beds at the inner border of the tertiary area, and well in among the high ranges, may represent the Siwalik conglomerates.

One of the most interesting observations we made this season was the demarcation of a great inlier of old limestone within the tertiary area. The extreme north-west end of this feature at Dandli close to the Púnch river was noticed in my Memoir of 1862 (loc. cit., p. 89), and I have now to apologise for having given a mistaken reading of it, which has led to some confusion. I was sent up there in 1859 to report on an outcrop of coal at Dandli. I had only one day on the ground; and, fresh from the Simla region, I was too hasty in applying its features to this remote section. I at once recognised the Subáthu group at Dandli, crushed up at the south base of a great ridge of old limestone. Throughout the Simla region there is no carbonaceous band in the Subáthu group; but, owing to deep unconformity and crushing, this group is very frequently brought into contact with infra-Krol carbonaceous shales. The superficial similarity of these sections, in parallel geographical positions, led me astray. The coal of Dandli belongs to the nummulitic formation; and the limestone is not presumably Krol.

The first appearance of this inlier is eighty miles to south-east from Dandli, some seven miles north-west of Udampúr. It is not continuous throughout this distance, as there is no sign of it in the valley of the Bari-Táwi between Náoshera and Rájáori; but all the outcrops occur along the same line of flexure and upheaval. *It is noteworthy that this line is on the general extension of the middle tertiary break of the Simla region, the outer boundary of the Sirmúr zone.* The principal mass of limestone is at the south-east end, where for a length of thirty miles it forms a lofty picturesque ridge, through the very centre of which the Chenáb has cut a precipitous gorge, just north of Riássi.

The structure of this feature throughout conforms to that which is so dominant over the whole South Himalayan region, a normal anticlinal flexure, broken and faulted on its steep outer face. Besides this familiar transverse structure, the clearly defined outcrop of these groups betrays a regular longitudinal waving of the stratification. The interrupted outcrop with intervening younger rocks suggests this; and the detail shows it more clearly. At each end of these ridges the beds curve continuously round the point of the anticlinal as it becomes depressed. The river courses seem to have little fixed relation to this feature, the two Táwis cross on lines of depression; the Chenáb cuts through the middle of the Riassi ridge; the Púnch cuts the point of the Dandli ridge; and several minor streams specially to affect clefts or chasms across these steep ribs of hard limestone.

The relation of the Subáthu group to these limestone masses is most uniform; not only is there complete parallelism of stratification, but the beds in contact seem to be the same throughout. This is most markedly the case in the nummulitic group, the bottom bed everywhere being the peculiar pisolitic clay, identical with that I described as a bottom bed of the group at Subáthu (loc. cit., p. 78), and also identical with that in the same position on Mount Tilla at the east end of the Salt Range. It is normally a ferruginous layer, but the removal of the iron often leaves it nearly pure white. The coaly band with some shaly clays immediately overlies it; to which succeeds the limestone. Immediately under the Subáthu bottom bed there is very commonly found a sort of silicious breccia. The perfect angularity of all the fragments forbids the idea of their having undergone any transport, as would *primâ facie* be suggested by the occurrence of such a band over a very large area, and often when the bedding has undergone no contortion. In this rock iron-ore has been extensively mined at many places, especially on the Sangar-Marg ridge. I believe the rock to be a shattered condition of a sandstone band that often occurs at the top of the great limestone series. The ore is a cellular limonite occurring in nests and strings through the breccia; it is probably derived by decomposition and infiltration from the coaly band of the Subáthu group.

The great limestone itself is a dense cryptocrystalline rock, in this respect contrasting strongly with the compact and often earthy nummulitic limestone close above it. It is often thin-bedded, locally cherty, and occasionally has intercalated bands of silicious slates and flags. The aggregate thickness of the formation must be great. We could nowhere find any trace of fossils in it, and I could see no special points of resemblance in it to the Krol group of the outer Himalaya east of the Satlej. On the more gentle northern slope of the range the Subáthu group stretches high up along every spur; and the pisolitic bottom bed with its attendant quartz breccia occurs on the highest summits. It will be seen how this relation of the nummulitic zone here to the underlying formations agrees with that in the trans-Jhelam country, and contrasts with its total unconformity in the Himalayan region east of the Satlej.

At Kotli on the Púnch we have the feature representing the middle tertiary break of the Simla region, being the outer boundary of the inner tertiary belt. It is here a double folded-flexure, with inversion between the axes, and faulting along the inner (anticlinal) axis. On the strike to the north-west towards the Jhelam the compressed flexure expands, the faulting dies out gradually, and upper beds stretch across the anticlinal axis. We were not able to follow this line up to the Jhelam, but these changes in it are the same as occur in all these features as they approach the Jhelam; the faulting which is so common along the main flexures in the Sub-Himalayan region dies out; and in many cases the flexures themselves cease and are taken up, on the new strike west of the Jhelam, by representative, not continuous, features. The two main north-west south-east anticlinal flexures outside the Kotli dún seem to bend continuously into the north-east south-west anticlinals on either side of Mount Nar, west of the Jhelam. I had not time to follow them so far; but I got a very near view from the summits east of the river. The synclinal of the Sensar dún, between those anticlinal ridges, certainly rises with a steep south-east dip in the ridges flanking Mount Nar on the south-east and well seen at the Owen ferry.

The less defined flexures of the lower Jamu hills are also traceable into connection with the trans-Jhelam lines. The anticlinal crossing the Púnch to north-west at Suru bends round and runs into a branch of the Bakrála north-east flexure below Dangli ferry on the Jhelam. The main representative of the Bakrála anticlinal continues on to Sálgráon, where it merges into several minor transverse corrugations. Similarly, the broad north-north-east anticlinal of Lehri and Godári sinks into the synclinal area of Chaomúk; and further south, the Rhotás north-north-east anticlinal spreads and sinks into the synclinal outside the last branch of the Himalayan flexures, north-east of Bhimbar. On the whole, the transverse line of the Jhelam would seem to be one of comparative depression; although, of course, the deepest section visible, the lower zones of rock are not so exposed along it as on parallel sections to the south-east. The river itself observes no rule in its windings amongst the points of these opposing flexures.

I could detect nothing definite in these mutually accommodating structural features to prove that either system is younger or older than the other. They fit into each other in a way that could only be effected by a simultaneous growth. The continuity of strike observable in each could not obtain if the strata had previously been affected by undulations of the other. Of the two, however, the strikes are much more steady in the north-west south-east system; a fact which may, perhaps, suggest that they had somewhat the start in their alignment. The great Bakrála flexure is almost serpentine in its windings. The form also of the north-east south-west flexures is less regular; and in its variation betrays the dominance of the Himalayan thrust: while to the south-west, the steep side of these flexures is almost uniformly on the south-east; to the north-east the steeper side is to the north-west. It is so in the Lehri anticlinal, and in the Bakrála flexure north of the Kasi.

In following the tertiary zones south-westwards from the Himalayan border to the Salt Range, some important changes are very marked. As is usual in the proximity of all the great Himalayan rivers, the Siwalik conglomerates attain an enormous special development near the Jhelam. They are finely exposed in the hills west of Sálgráon, where it is well seen how this character is due partly to encroachment upon the lower zone. When not in force, the conglomerates are confined to the topmost earthy-brown portion of the series; this band is largely represented here; but below it the grey sandstone is strongly conglomeratic for a thickness of several hundred feet. These coarse deposits decrease greatly to the south, and become confined to the topmost beds, as described by Mr. Wynne in the Kharián or Pabbi hills, south-east of Jhelam (Rec. Geol. Surv., Ind., Vol. VIII, p. 48).

The main fossiliferous zone of the Siwaliks continues in great force to the south. The uncertainty of our measurements of them does not admit as yet of any close comparison in this respect. Mr. Theobald has again during this season made a good collection from these beds, principally in the area immediately north of the Salt Range, between the Tilla and Bakrála ridges. Mr. Lydekker, when he returns from the field, will no doubt give a good account of them.

In the lower zone we again find a very marked contrast from north to south along the Jhelam, between the Sub-Himalayan region and the Salt Range. We have seen all along the former ground that the Subáthu-Dagshai boundary is the most unsettled of any in the Sub-Himalayan tertiary series; stray thin layers of nummulitic limestone being locally found high up in the purple clays transitionally overlying the distinctive Subáthu zone. In the Salt Range, on the contrary, this is the most marked boundary of any; thick, softish sandstones and clays rest abruptly on the clear nummulitic limestone. The commonest junction-layer being a conglomerate made up of water-worn pebbles of the limestone and its flints, I described the contact in my Memoir of 1862 (p. 91), as one of denudation. I do not think the term a misleading one for such a junction, although Mr. Wynne very properly insists upon the constant parallelism of the stratification in the two groups, and upon his failure to find even a single case of actual erosion in the lower group filled in by the upper one. It is quite evident, however, that a very considerable break in the tertiary series occurs at this horizon in the Salt Range, amounting, I should think, to several hundred feet of the Subáthu and immediately supra-Subáthu zones of the Himalayan sections.

An important formation not yet mentioned came largely under our notice in the Sub-Himalayan hills—high-level river-shingle capping the ridges and spurs of upturned tertiary strata and packed against their flank at fully 400 to 500 feet over the actual river courses, which must have been eroded to at least that depth since the period of these deposits. There is evidence also to show that to some extent at least this was a re-excavation of the channels out of these deposits, *i. e.*, that the existing rock-gorges had been to a great extent cut out before their accumulation, then filled by them, and subsequently cleared out again. Bubhór stands on a great bank of these beds packed against a ridge of vertical Siwalik conglomerates; and the bottom beds are seen to pass continuously for some way up the gorge of the Satlej, while the top beds of the same set are found capping the inner ridge of grey sandstone above Naili. They are unquestionably of very ancient post-tertiary date.

The distribution of this formation in the hills is generally limited to a greater or less distance from the great river courses; a fact which seems simply a question of levels; the flat watershed of the dúns being commonly 500 to 600 feet over the main drainage level.

The supposed glacial deposits of the Kángra valley would belong to this old diluvial period. I must mention that though we were unable to account for the distribution of the great erratics otherwise than by glacial action, Mr. Leydekher and myself were unable to find the moraines so graphically described by Mr. Theobald (Vol. VII, p. 86). The features so named are, I believe, only ridges of erosion out of a deposit that must once have filled the whole valley, remnants of it being found on the outer ridge high over Kángra fort.

The same deposits are largely displayed about the Jhelam, capping the Rhotás ridge on both sides of the Kahán; and on the Potwár, filling the valley of the Sohán, and covering the country for some distance from the Bakrála and Tilla ridges with large blocks of stone, for the transport of which it is difficult to account. Mr. Theobald strongly advocates their glacial origin, finding what he considers evidence of an ice-stream from the south-east flank of Tilla, past the villages of Hunúla and Hún, to within about 1,000 feet of the sea level.

As the principal object of our season's work, it is necessary to say something of the correlation of these tertiary groups, especially since, in the absence of direct information, conjectural affiliations have been published by the Survey—by Mr. Wynne in his Memoir on the Kohat Salt Region (Mem., Vol. XI, 1875), and by Mr. Blanford in his paper on the Geology of Sind (Rec. Vol IX, 1876). The former finds representatives of all the lower tertiary zones in the Kohat and Salt Range sections, and almost excludes the Siwaliks (see table, p. 24); while the latter runs the Siwaliks and Náhans together as equivalent to his Manchar (pliocene) group (p. 21). It is but right to explain that these opposite mistakes are largely due to some unpublished work of Mr. Theobald's in 1873-74, who, starting from the Satlej, somewhat arbitrarily restricted the Siwalik group to the outermost range of hills, and mapped all the rest as Náhans, up to the trans-Jhelam country, although finding in them fossils of the Fauna Sivalensis, the object set before him being to work out the presumed distinction of the Náhan and Siwalik faunas. Mr. Wynne accepted his stratigraphical identifications, and Mr. Blanford on his side was equally right in insisting that there was a very close affinity between the fossils said to be from the two distinct horizons.

Whatever value may be ultimately assigned to the unconformity which originally suggested the separation of the Náhan group in the Cis-Satlej region, the distinction of the zone as a comparatively barren formation at the base of the great mammaliferous Siwalik deposits will hold good, even if the fossils, whenever discovered, should make it desirable to designate the group as lower Siwalik. It has now been traced with fair certainty into the trans-Jhelam country, where it is represented by several hundred feet of sandstones and clays immediately overlying the nummulitic limestone on the east end of the Salt Range. It may not unlikely be the equivalent of Mr. Blanford's Gáj (miocene) marine group in Sind.

It seems very doubtful whether it will be practicable or desirable to separate this band from possible representatives of the upper Sirmúr strata, in the vastly greater thickness of purple sandstones and clays transitionally overlying the Subáthu group in the Himalayan region proper, to the north of the Salt Range. We may be well satisfied if we can make out there an assignable boundary for the top of the Subáthu group. This remains to be done.

A word is necessary on the Subáthu group itself: at Subáthu, where it was first brought to notice through the collections of Major Vicary, described by D'Archiac and Haime, and all along the Himalaya up to Mari, the formation is principally made up of brown, olive, and red clays, with subordinate earthy limestone; the base of the group being very sharply defined throughout by very characteristic beds resting upon much older rocks. In my Memoir of 1862, owing to the mistake already noticed regarding the coal of Dandli, and other causes, such as the specific difference of the fossils as noted in D'Archiac and Haime's work, I remarked upon the want of agreement between the Subáthu group and the nummulitic band of the Salt Range. From the continuous observations of this season I was greatly struck by the remarkable correspondence between the thin nummulitic band at the east end of the Salt Range and the very base of the Subáthu group. The point is important with reference to the great change that takes place in the formation to the westward, both in the northern and southern region—the immense and rapid increase of limestone. From Mr. Wynne's description of the Mari ground, it would appear as if the "Subáthu group" overlay his "Hill nummulitic limestone;" but I am disposed to think, and information sent me by Mr. Lydekher strengthens the notion, that this great limestone takes the place of the upper Subáthu deposits. The coaly band, common to both regions, continues at the base of the formation all through the Salt Range and beyond it to the west. Thus it appears possible that the Subáthu group of the Himalayan region may contain representatives of Mr. Blanford's Nari and Kirthar groups, and even of his Ranikot beds, in Sind.

Our observations of this season have strongly brought before us the necessity of indicating an upper division in the Siwalik group of my Memoir of 1862, to represent the great conglomeratic zone and its equivalents at the top of the formation. We found repeated confirmation of my remark that the distribution of these Siwalik conglomerates is coincident with the proximity of the Great Himalayan rivers, they being generally represented elsewhere by brown clays undistinguishable from recent alluvium, or, if conglomeratic in this position, the pebbles are of local débris, not the hard torrent-shingle of the great conglomerates. There is no better example of this than at the Satlej, where there are some 4,000 feet of deposits highly conglomeratic throughout and very coarse in the upper portion. All are vertical, the strike being most easily followed continuously; and thus, within seven miles of the Satlej, in the parallel section above Basóli (Madanpur), we find only about 500 feet of conglomerate in the middle of over 3,000 feet of brown sandy clays. It was in these beds that Mr. Theobald found remains of *Bubalus* and *Camelus;* and Mr. Lydekher insists upon their separation from the main Siwalik deposits on palæontological grounds, suggesting that they may be the same as the Narbada fossil-beds. Upon this question of identification I think further consideration is needed. If the old alluvium of the Gangetic plains, which Falconer identified with the Narbada bone beds, are the equivalents of these vertical upper Siwalik strata, where in the plains are we to look for the representatives of the very ancient high-level terrace deposits already described along the base of the Himalaya as post-tertiary? I am inclined to think that these may rather be grouped with the old valley-gravels of the Peninsula. The gap between them and the top Siwaliks must be very great.

*(An outline-map for this paper will be given in a later number).*

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RECORDS

OF THE

# GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1876. [August.

## NOTES ON THE AGE OF SOME FOSSIL FLORAS IN INDIA, *by* OTTOKAR FEISTMANTEL, M. D., *Geological Survey of India.**

### III, IV AND V.

In the last number of the Records I had occasion to discuss the relations of some local fossil floras of India, and from those relations, after a thorough comparison of our floras with others, I attempted to draw natural conclusions regarding the age of the rocks in which the plants occur. I began with the highest groups of the Gondwána series, and gave a list of fossil plants found in the plant-beds in Kach, and in those interstratified (partly) with the volcanic formations of the Rájmahál hills. I also referred the flora from Golapilli, (Kolapilli) near Ellore (Madras Presidency), to the same age as the Rájmahál group.

Proceeding in natural order, I should next describe the other local floras more or less closely allied to those mentioned above, *i. e.*, to the Kach and Rájmahál groups. Such local floras are found in the Jabalpúr group of the Satpúra and South Rewah areas, the Sripermatúr beds near Madras and the Trichinopoly plant-beds. I will, however, postpone the consideration of these for the present, in order to give a preliminary sketch of the floras found in the lower groups of the Gondwána system, which are palæontologically more interesting, as determining the geological range of this system as a whole.

The groups to be noticed in the present paper, according to the classification adopted by the Geological Survey of India, are the following :—

*a.*—The Panchet group.
*b.*—The Damúda group.
*c.*—The Tálchir group.

However opinions may differ as to the age of these three groups, as indicated by their floras, I do not doubt for a moment that all belong to one geological epoch—the Trias. Their precise age, in each case, will be shown by a discussion of each flora separately. I should consider it a great palæontological mistake on my part, and it would show want of knowledge of the literature, were I to decide otherwise, for it seems to me incorrect to suppose that the floras of these groups cannot be compared with a well known fossil flora in Europe, and to refer them instead only to a less perfectly known flora in Australia, with which some of our plant-beds have by accident one or two genera in common. On the other hand, several important genera found in the fossil floras of India are identical with

* Continued from p. 12

those described from a well known and defined horizon amongst the rock-systems of Europe, while not one of the animal fossils, which serve to determine the age of the lower portion of the Australian coal strata, has ever been found in our series.

I regret only that the provisional determinations of the plant remains given by Mr. Oldham in his paper in the Memoirs, vol. II, have been misunderstood, and have given rise to wrong conclusions, as the present state of our knowledge shows that the real relations of the fossil plants are different from what they were formerly supposed to be. For any safe inference the following conditions must be fulfilled:—

1.—Only a thorough determination of the fossil remains can be used for the determination of the age of the series.

2.—The comparison must be made with all the known floras, and not only with one, especially if that one be not typical.

3.—Where, besides the fossil plant remains, there are no fossil animals, the typical plants must determine the age of the groups, especially if the species of plants are identical with other well known and characteristic forms found in formations of well determined age.

4.—The conclusions must agree with all laws of Palæontology; if one law is abandoned, the conclusions are uncertain, and contradictions appear which are unnatural.

5.—It is not unnatural that certain genera having a wide range in time should be common to several series. They can, however, be of no important influence in fixing age, which must be determined by the other fossils with which they are associated.

For instance, there is nothing strange in the same species of *Ptilophyllum*, Morr., occurring both in the Rájmahál series (Lias) and in the Kach series (lower Oolite), nor in some species of Ferns or *Equisetaceæ*, being found in the Carboniferous and Permian; and similarly there is no reason why a certain species of the genus *Glossopteris*, Brgt., occurring in our Damúda series, the flora of which is really Mesozoic, should not also be found as well (and perhaps prevail) in some of the supposed Palæozoic coal strata of New South Wales.

We shall see that characteristic species are found in the Panchet group and throughout the Damúda formation, and that these species clearly define the age of the beds, while *Schizoneura* is common to both, and proves that both belong to the same great epoch. The Damúda group has no real connection with the lower coal-beds of New South Wales, although *Glossopteris*, Brgt., occurs in both, and in Australia (but only in the lower strata) is associated with marine fossils of palæozoic age. The plant-beds of Kach and those of Rájmahál, as was shown in the last number of the Records, are, it is true, of different ages, but yet belong to the same great epoch, and are related by the occurrence of certain species of the genus *Ptilophyllum*, Morr.; in the same manner, we shall find that the three series now to be described are also connected together by common forms: that the Panchet group is connected by a species of *Schizoneura* with the Damúda, and these latter again with the Tálchirs by *Gangamopteris*; proving that all these three, though of different age, belong to the same epoch. There may be, and of course are, other opinions about the age of these groups. I can only remark, *that as long as no other proofs are found, the fossils alone can serve to decide the geological age,* agreeing, as they do, with other well known species from well defined series; and as these are all well known fossil plants, these must decide.

## III.—FLORA AND PROBABLE AGE OF THE PANCHET GROUP.*

In his paper on "the Raniganj coal-field," l. c., Mr. W. T. Blanford described some beds overlying the Damúdas as the Panchet group. From this group, both animal and plant remains are known. The first have been already described by Prof. Huxley in the Palæontologia Indica, Ser. IV, No. I, and determined as bones of *Labyrinthodonts* and *Dicynodonts*. Besides these some *Estheriæ* were also found. These animal fossils, in connection with the plant remains, amongst which Mr. Oldham recognised some triassic forms, led to an approximate determination of the age of the Panchet group. This we find expressed on page 205 of Mr. *Oldham's* paper, l. c. (Mem. III) in the following words: "..... I feel no hesitation in expressing my belief that the Panchet group of the present report represents the earliest portion of the great mesozoic division in the general geological scale, or, in other words, is of about the same age as the Buntersandstein and Keuper of Europe."

There is only to be remarked, that to this group cannot be attributed the age of two different European strata (as Buntersandstein and Keuper are). From a comparison of the plants I must as I shall show, accept the age of the Keuper for our Panchet group.

Mr. Oldham gave also a provisional list of the plant remains (Mem. III, p. 204) which has been reproduced in a recent paper of Mr. H. F. Blanford.†

The list was—

| | | |
|---|---|---|
| *Schizoneura,* | 1 | species. |
| *Tæniopteris,* | 1 | " |
| *Sphenopteris,* | 2 | " |
| *Neuropteris?* | 1 | " |
| *Pecopteris,* | 2 | " |
| *Preisleria,* | 1 | " |

Of these I have been unable to find any *Sphenopteris* or any true *Neuropteris*, whilst with regard to the doubtful genus *Preisleria*, Presl, we now know from the investigations of Prof. Schenk, that in the specimens which Presl described‡ the leaf fragments belong to *Zamites distans*, Presl, and that the flower or fruit-like figure (fig. 10) is an artificial production, as I will point out hereafter. Our fossils, which Mr. Oldham compared with *Preisleria*, are, as I think, more probably the fructification of some equisetaceous plant.

As I shall before long have occasion to speak of these plant remains, as well as of the others, in more detail, with illustrations of the best of them, I will here only briefly notice the most important—

### *A—EQUISETACEÆ.*

Remains of equisetaceous plants are of frequent occurrence; one very important genus being especially abundant.

#### *Genus:* SCHIZONEURA, *Schimp.*

(Schimper et Mougeot: Monogr. d. pl. foss. du Grès bigarré des Vosges, 1844.)

Schimper and Mougeot described this peculiar genus from the "Grès bigarré', (Buntsandstein) of the Vosges-mountains. But it has since been found also in Keuper and in Rhætic. There are in all about four species known.

* *Vide* W. T. Blanford: Memoirs, Geolog. Surv., III, Part I, pp. 29, 126, 132, &c.
" Th. Oldham: Additional remarks on the geological relations, etc. Mem. Geol. Surv. III, p. 197.

† Quart. Journ. Geolog. Soc., 1875: On the age and correlation of the plant-bearing series of India, etc.

‡ Sternberg, II, tab. XXXIII, f. 5—10.

Our species from the Panchet is distinguished from those previously described by the dimensions of the leaflets (on the spathes), which are broader. It comes nearest to *Schizoneura paradoxa*, Schimp.-Moug., from the Vosges sandstone. As I think I am justified in considering this species from the Panchet group as identical with that from the Ránigani group (Damúda), I shall describe it under the following name:—

1. *Schizoneura Gondwanensis*, Fstm. The description will be given farther on under the Damúda flora.

This species is of great importance; both because it is of influence in the determination of the age (for these broad-leaved forms are only found in the Trias), and because it serves to connect the Panchet with the upper portion of the Damúda (Ránigani group); as this species is found in both groups of the lower portion of the Gondwána series I name the species *Gondwanensis*. There occur also a great variety of stalks, stems, and evidently also Rhizomes and rootlets, belonging no doubt to this genus.

The fossils which Mr. Oldham identified with Presl's genus *Preisleria* I am inclined to look upon as the fructification of *Schizoneura*: they have certainly nothing in common with the form described by Presl. I have already mentioned that Presl's figure was taken from a specimen which had been altered by artificial means. Schenk* has proved that Presl's figure† belongs to *Zamites distans*, and he considers that the markings which were taken for inflorescence *were produced by painting the specimen* with Indian ink.‡

## *B.—FILICES.*

Amongst these, there are two species of importance for the determination of the age. *The most abundant is*—

1. *Pecopteris concinna*, Presl. Sternberg: Fl. d. Vorw. II, Tab. XLI, fig. 3.

A fern, of which we have several specimens found in a greenish grey soft sandy clay which has not been quite suitable for the preservation of the tender parts of the fronds; still our specimens agree *exactly with Presl's figure.*

Mr. Oldham recognized *this* species, and says on page *205 of his paper (Mem. III)*: "A *Pecopteris* is undistinguishable from *P. concinna*, Presl, a triassic (Keuper) form." It is true that Presl and other authors after him considered the locality of *P. concinna*, Presl, (Hoefen near Bamberg) as Keuper, but Schenk has shown that this locality as well as several others belong to the Rhætic formation, intervening between Keuper and Lias. Nevertheless, on account of its occurrence with *Schizoneura Gondwanensis*, Fstm., I will consider it Keuper.

The other species is—

2. *Cyclopteris pachyrachis*, Göppert: Gattungen der foss. Pflanz., Lief. 5, 6, p. 94 Tab. IV, V, figs. 13, 14.

This fossil was originally described from Bamberg, and was supposed to have been found in beds belonging to the Keuper. Other authors, including Schenk, have described it under the same name; but the last named writer, from a special examination of the ground, has proved that the locality at which the fossil was procured belongs to the Rhætic beds, and its position is nearly the same as that of *Pecopteris concinna*, Presl.

* Beiträge zur Keuper-und Bone-bed-flora, p. 57.

† Presl in Sternberg, Vers. II, Pl. XXXIII, fig. 10.

‡ Schenk, Grenzschichten-flora, p. 162. "Das Original der fig. 10, in der Kreissammlung zu Bayreuth befindlich, verdient gar keine Beruecksichtigung, es ist mit Tusche bemalt und sind die runden schwarzen Stellen mit Farbe aufgetragen, das Blatt gehört wahrscheinlich ebenfalls zu *Zamites distans*."

Schimper has more lately transferred *Cyclopteris pachyrachis*, Göpp., first to *Neuropteris*, Brgt., and in the last volume of his Paléontologie végétale (III, p. 476,) to *Pecopteris*.

Besides these two very well marked species of ferns there are some more indistinct fragments, only one of which requires notice here. It is a species of *Tæniopteris*, Brgt., which, from the general habit of the frond and its coriaceous appearance, must, I think, be referred to *Oleandridium*, Schimper, and is evidently somewhat allied to *O. stenoneuron*, Schimp, (Schenk) from Rhætic beds.

In general, therefore, the Flora of the Panchet is very poor; but still it is sufficient for comparison with other Floras, and for determining the age, at least with some probability. All the fossil plants hitherto found in the Panchet rocks are from one locality south of Maitúr, on the west branch of the Núnia in the Rániganj field.

Amongst the Panchet fossil plants *Schizoneura Gondwanensis*, Fstm., is the most important form.

If we now turn to the determination of the age, we have, excluding the reptilian remains, especially to consider three very well marked species, which at once indicate an age lower than Jura (including Lias). Of these three plants, two, *Pecopteris concinna*, Presl, and *Cyclopteris pachyrachis*, Göpp., (as well as, perhaps, the *Tæniopteris*, Brgt.,) would indicate the transition series between Keuper and Lias; but the occurrence of *Schizoneura Gondwanensis*, Fstm., which on the one side is allied to the European broad-leaved species *Schizoneura paradoxa*, Schim.-Moug., from the Vosges (Buntsandstein or grès bigarré), on the other side is the same as the *Schizoneura* so abundant in the Rániganj group (Upper Damúda), which also, as will be seen, is lower Triassic (grès bigarré), induces me to take the plants altogether as indicating a rather lower age, and I do not hesitate to consider them all as Keuper, a position which is moreover not at all in contradiction with the evidence of the reptilian bones, and with Mr. Oldham's already pronounced opinion (Mem. III). *The Panchet group may be therefore taken as representative of the highest* Trias (Keuper).

I think also the animal remains of this group will not be opposed to these observations, as they agree very closely with many reptilian remains known from the Rhætic of Bayreuth (Verzeichn. der Petref' z. Bayreuth; F. Braun, 1840).

This group is allied, through *Schizoneura Gondwanensis*, Fstm., with the Damúdas, in the first place with the Rániganj group, and through this with the whole formation.

### IV.—Flora and probable age of the Damúda Formation.

This formation is largely developed in India; it is also the most important, as it includes the deposits of the so-called "old coal" of India. We find it in Bengal, South Rewah, Sátpúra Range, on the Godávari and in the Eastern Himalaya. I need not mention anything about the stratigraphy of this series, as this has been done in the publications of our Survey.*

* The most important notices are—

Memoirs I.—On the geological structure and relations of the Tálchir Coal-field in the district of Cuttack. (W. T. and H. F. Blanford, and W. Theobald).

Memoirs II.—On the geological structure of the central portion of the Nerbudda District. (J. G. Medlicott).

" " On the geological relations and probable geological age of the rocks in Central India. (by Mr. Oldham).

Memoirs III.—On the geological structure and relations of the Ránigunj Coal-field, Bengal. (W. T. Blanford).

Memoirs VI.—The Bokaro Coal-field. (Th. W. H. Hughes).

" " The Ramgurh Coal-field. (Hughes).

Memoirs VII.—Kurhurbari Coal-field. (Hughes).

Deoghur Coal-field. (Hughes).

It is quite possible and not unnatural that the whole group may be divided stratigraphically and lithologically into the three sub-groups which have been proposed, *viz.*—

| | |
|---|---|
| Ráníganj and Kámthi group | (upper Damúda). |
| Iron stone shales | (middle do. ). |
| Barákar | (lower do. ). |

But with reference to their palæontological relations, we must consider all these as belonging to the same age, for the whole of the fossil plants, taken together, exhibit a distinctly limited general character such as is found in a well defined group in Europe. One genus also occurs in the lower coal-strata of Australia, and consequently a corresponding age has been inferred for our coal-bearing rocks, but, I think, incorrectly, for the other plant remains from our Damúda formation which are so very characteristic are not found in Australia, and even the greater part of our species of *Glossopteris*, Brgt., are distinct from the Australian, and also in Australia the same genus occurs in the upper portion of the coal-strata without any fossil animals, but with mesozoic plants, and is most abundant at this horizon. I therefore consider that—

*a.*—In Australia there may be fossil remains of animals which determine the age of the series, although a certain species of *Glossopteris*, Brgt., is found with them.

*b.*—In India, on the other hand, as no fossil animals have been found, the age of the series must be determined by the other plants, notwithstanding the occurrence of *Glossopteris*, Brgt.

I look upon the occurrence of *Glossopteris*, Brgt., in the Damúda formation as offering a parallel case to the presence of *Ptilophyllum*, Morr., in the Rájmahál and Kach groups: it is an interesting plant, but without direct influence in enabling us to determine the age of the beds. My conclusions are the following, *that Glossopteris*, Brgt., *began to exist in the lower coal-strata of Australia, where it is said to be associated with fossil animals of carboniferous age, and continued in our Indian coal series, which, however, are characterised by some very well defined genera, which indicate another, and a mesozoic age* as in the upper portion of the Australian strata and in Africa. A more exact determination of the age will result from the comparison of the fossil plants.

It has been, and will perhaps yet be, endeavoured to show that the Indian Damúda series are of palæozoic age, but I do not see where is the proof, as the palæontological results, *the only possible proofs*, indicate *lower mesozoic*, as will appear from the following facts :—

*a.*—There is no other connection between the Indian rocks and the lower portion of the coal-strata of Australia except the occurrence of *Glossopteris*, Brgt., in both; it is, however, much more developed in India.

*b.*—The chief evidence that no *Tæniopteris* occurs in the Damúda (Oldham, Memoirs, II, p. 329, and some others), has been shown to be a mistake, as there are found in the upper portion distinct species of broad-leaved *Tæniopteris*, Brgt., with mesozoic characters *(Macrotæniopteris)* Schimp., as I will show more fully further on.

Memoirs IX.—Geology of Nágpúr. (W. T. Blanford).
Memoirs X.—Sátpúra Coal-basin. (Medlicott).
Memoirs XI.—Geology of Darjeeling. (Mallet).
Besides these I will mention only—
*Bunbury.*—Fossil plants from Nágpúr. Quart. Journ., Geolog. Soc. 1861, Vol. XVII, p. 325.
*Royle.*—Illustrations of the Botany, &c., of the Himalayan Mountains. (Plants from Burdwan).
*Mc'Clelland.*—Report of the Geological Survey in 1848-49 (Damoodah plants).

*c.*—The Damúda *Sphenophyllum* (*Trizygia*) proves quite different in habit from those of the carboniferous period.

*d.*—The discovery of *Voltzia* and *Neuropteris* with single pinnæ (triassic forms) in the Barákars is very important.

*e.*—In the Barákars there are forms of a genus allied to *Glossopteris* (*Gangamopteris* from the upper-portion of the Australian coal-strata), which is almost the only fossil found in the Tálchirs; by it these latter are connected with the former.

Having established these general views, I proceed to discuss the fossil plants, which afford additional evidence in favor of my opinions. I can, of course, only describe the most important fossils. A thorough discussion of all the plant remains will be given in the Palæontologia Indica.

## *A.—EQUISETACEÆ.*

These are very abundant, and one genus is especially important, as bringing the Damúdas into relation with the Panchets, and showing that both belong to the same epoch as a European formation, in which the same genus is well known. This genus is—

### *a.*—SCHIZONEURA, *Schimp. & Moug.*

This genus is especially abundant in the upper portion of the Damúdas. It is found of different sizes, and in various states of development, but everywhere there is only one kind of leaves (spathes), and everywhere they have the same characters. They are very near to those of *Schizoneura paradoxa*, Schimp. & Moug., which they resemble in the mode of connection of the leaflets in two parts of the spathe. Only one specimen is known in which the separation of the leaflets is nearly complete, and this specimen closely resembles Schimper's figure, Pal. Végétale, Pl. XIII, fig. 8. I have no doubt that this specimen belongs to the same species as the others. As I consider that the *Schizoneura* of the Panchets is the same as that in the Damúdas, I will use the same name for both—

*Schizoneura Gondwanensis*, Fstm.

Diagnosis:

*Caule articulato, striato, variabili altitudine ac latitudine; foliis* (*foliolis*) 12—22; *plerumque in duas partes vaginæ coalitis; nonnunquam etiam liberis, suberectis, foliolis in duas partes connexis, folia oblongo-ovalia exhibentibus; usque ad* 14·5 *centm. longis, et media parte* 2·5 *centm. latis,* 7—11 *nervos continentibus.*

This diagnosis of this species is, of course, the same for the form from the Panchet group: the habit and the characters are identical in both, only the Panchet forms are in general a little smaller.

As the only difference from the Vosges species *S. paradoxa*, Schimp. and Moug., is in the number of the leaflets, I consider that the two forms are nearly allied, and I look upon our species also as Triassic (Bunter-Sandstein). The fossils described as *Zeugophyllites*, Brgt., from India by Brongniart (Prodrome 121-175) and subsequently by Strzeecki (Phys. descr. of New South Wales, &c.) seem to belong also to *Schizoneura*, as well as the fossil described by Mc'Clelland (l. c. Pl. XIV, fig. 4), as *Zamia Burdwanensis*, Mc'Cl.; there is, however, as far as I know the literature, nothing like *Schizoneura* anywhere mentioned as occurring in the lower coal-strata of Australia.

### b.—Sphenophyllum, *Brgt.*

In the Damúda formation, both in the upper portion and in the lower, some equisetaceous fossils occur, which were described by Royle as *Trizygia speciosa*, l. c., p. 431. There is no doubt that these fossils belong to the well known genus *Sphenophyllum*, Brgt., and we find them described in Unger's 'Gen. et sp. plant. foss., p. 70, under the name of *Sphenophyllum trizygia*, Ung. Mc'Clelland (l. c., p. 54) described the same form as *Sphenophyllum speciosum*, Mc'Clell., and pointed out quite distinctly that there was no doubt about its being a real *Sphenophyllum*, Brgt. But whilst there is no doubt about the identity of *Sphenophyllum* and *Trizygia*, I prefer Unger's name *Sphenophyllum trizygia*, as there is a constant character in the arrangement of the leaves in three pairs, each of two equal leaves, on one side of the articulation, the lowest pair of leaflets being the shortest, the middle longer, and the highest the longest. There are, therefore, never more than six leaflets, which do not form an entire whorl, but are arranged on one side. This arrangement is quite different from that found in all carboniferous forms, in which the leaflets are all nearly equal and form an entire whorl round the articulation; besides this, the stem of the Indian *Sphenophyllum* is in all cases very thin in relation to the size of the leaves. There can be no doubt about the nature of this species, which must have been a water-plant, expanding its leaflets at the surface of the water.

This *Sphenophyllum* is therefore different from all Carboniferous and Permian forms, and I adopt Unger's name *Sphenophyllum trizygia*, Ung. I have specimens from Burdwan (from the upper portion of the Damúdas, Ráníganj), and from Tálchir near Cuttack from the Barákars. I think there is only one species.

Besides these two well marked fossils, various stalks with articulations, ribs and furrows, are common, and are generally known as *Phyllotheca indica*, Bunb. I must say I have seen the real *Phyllotheca* such as Zigno described from the Oolitic formation, and as are known from the upper portion of the coal-strata in Australia (Newcastle), but I am very much inclined to consider a great proportion of the stems found in India as stalks of *Schizoneura*, Schimp.; some others may be indeed internal casts of mesozoic species of *Equisetum*. In Australia there is in the upper portion of the coal-strata also a real *Phyllotheca* in Zigno's sense (Newcastle); the *Phyllotheca* in the lower portion may be *Calamites* or *Equisetum*.

The very doubtful form, called *Vertebraria*, I consider to consist of roots and rootlets (Rhizomes), most probably of some equisetaceous plants, in the same way as the genus *Pinularia*, Lindl. and H., in the carboniferous strata, consists also of rootlets, most likely of *Asterophyllites*, Brgt.

*Vertebraria* abounds in the Damúdas, and appears to be characteristic of them as a series, but it cannot be quoted for the determination of the age, for which only *Schizoneura Gondwanensis*, Fstm., can be used. As far as I can tell from the literature, and from what I have seen of Australian fossil plants, *Vertebraria* is also known only from the upper portion of the coal-strata.

## B—FILICES.

In the same way as amongst the *Equisetaceæ*, the genus *Schizoneura*, Schimp. and Moug., is the prevailing form, so also amongst the *Filices* one genus is especially prevalent. This genus, however, cannot be directly employed as evidence of the age of the Damúda;

it is only by its relations to other forms that it can be used as collateral proof. It is only characteristic of the series. This genus is—

*a.*—GLOSSOPTERIS, *Brgt.*

However interesting this genus may be, it has, I think, been the chief cause of the confusion of opinions about the age of the series in which it occurs—I mean the confusion has been caused by the comparison of this genus with the same in Australia, where it is said to be found in palæozoic rocks. From this evidence also our Indian Damúda groups in which *Glossopteris* is very common have been taken for palæozoic, without considering that *Glossopteris* has in this case been found apart from animal remains which indicate a palæozoic age, but, on the contrary, only with plant remains, which are all mesozoic (Triassic).

I should consider it a great palæontological mistake if I were to take a series in which the majority of the plants are of mesozoic age, and identical or closely allied with well known mesozoic (Triassic) genera and species, to be of any other age than mesozoic, only because one genus is also found in it which is also known from a portion of the coal-strata in Australia. Nobody will class the Permian and Carboniferous as identical, although some species of plants or animals may occur in both.

We should rather say, some species of *Glossopteris* are found in the supposed palæozoic coal-strata of Australia, but the genus also occurs in great abundance in the lower mesozoic coal-strata of India.*

It is only remarkable that, while in Australia there are both fossil animals and plants of lower carboniferous age, of which the latter belong for the most part to genera identical with those found in Europe, there should be in the upper carboniferous (without fossil animals) a sudden change in the flora and no true carboniferous plant found.

But another locality is known for *Glossopteris*, Brgt.; this is in the Karoo beds of South Africa, described by Mr. Tate,† which series that author also puts in the Trias, and I think with justice. This would agree well with our series. Tate recognized in Africa the same forms which are most common here in India.‡

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* See a similar opinion by Mr. Dawkins in the transactions of the Manchester Geological Society, Vol. XIV, Session 1875-76, Part II, p. 28: Age of the New South Wales coal-beds. The manner in which Mr. Dawkins expressed himself is quite correct and natural, but I never before read anything about the association of the *Glossopteris* in Australia with *Lepidodendron, Sigillaria, Calamites, etc.*, these being only found below the lower marine beds.

† Quart. Journ. Geolog. Soc., 1867, p. 140 ff.

‡ I cannot discuss this subject further here, and I think it sufficient to quote the following literature about *Glossopteris*:—

*Brongniart:* Histoire des végétaux fossiles, 1818.
*Göppert:* Systema filicum fossilium, 1836.
*Mc'Coy:* On the fossil botany and zoology of the rocks associated with the coal of Australia. Annals of Natural History, Vol. XX, ser. 2.
*Bunbury:* Fossil plants from Nágpúr. Quart. Journ. Vol. XVII.
*Mc'Clelland:* Report, 1848-49; Calcutta, 1850.
*Dana:* Geology (United States Exploring Expedition), 1849.
*Tate:* South African fossils. Quart. Journ., 1867 (Vol. XXIII).
*McCoy:* Prodromus of Palæont. of Victoria, II Decade.
*Schimper:* Traité de Palæontolog. végétale.
*W. B. Clarke:* Remarks on the sedimentary formations of New South Wales, 1875.
Also all the publications in our Memoirs which I quoted before should here be repeated, especially Mr. Oldham's paper on the probable age of the rocks in Bengal and Central India (Vol. II).

The best known species of *Glossopteris*, Brgt., is *Glossopteris Browniana*, Brgt., of which Brongniart distinguished two varieties: (*a*), *Indica*, and (*b*), *Australasiaca*, which, however, have been described by Schimper as two different species, and I think correctly. I may add that in India the only prevailing form is that with longer and pointed leaves and much narrower reticulation, *Glossopteris indica*, Schimp., while the generally smaller form with a more obtuse apex and wider reticulation, *Gloss. Browniana*, Brgt., is much rarer in our strata, although it prevails in Australia, where it is the only species found in the lower portion with the marine fauna.

I am now preparing a monograph of the genus *Glossopteris*, Brgt., and some allied genera, in which I will enter more fully into details, and it will be seen that the pointed *leaves prevail in the Damúda, and also that of the figures of our Indian forms those in* Bunbury's *paper* (l. c.) *are the best, whilst* those in Brongniart and Göppert are not very correct.

*Brongniart described one form as Glossopt. angustifolia from* Ránigan*j; I have not found any specimen from India, but I have seen one from* Australia, *from the upper portion* of the coal-strata.

Besides these I have been able to distinguish a great many species, or at least varieties, also young fronds, etc.

Near Nágpúr several specimens have been found with fructification, with 1—4 rows of sporangia between the stalk and the margin, which, together with the reticulate nervation, tend to indicate a relationship between *Glossopteris* and some living species of *Polypodium*. On one specimen of the Australian *Glossopteris*, Brgt., Mr. Carruthers seems to have observed a different fructification, consisting of linear sori along the veins, but nearer to the margin of the leaf. (See Carruthers in Daintree's paper on the Geology of Queensland. Quart. Jour., Geol. Soc., 1872). This would prove further the difference between our *Glossopteris* and the Australian species.

The best known forms are therefore—

1. *Glossopteris indica*, Schimp.—large pointed leaves, narrow reticulation. Sori in rows on the surface of the frond.—Prevailing in India.
2. *Glossopteris Browniana*, Brgt., Schimp.—smaller obtuse leaves, wider reticulation. Australian form; the only species found in the lower strata.
3. *Glossopteris angustifolia*, Brgt.—different in the nervation, known from the Damúdas and the upper portion of the coal-strata in Australia.

Other species will be shewn to exist after the special examination of this genus.

There are, besides these, several species described by Bunbury and McClelland, but McClelland's figures (l. c.) cannot be recognized, as they are not accurately drawn. I need only mention *Glossopteris acaulis*, McClell., Tab. XIV, f. 3, 3*a*, which is not sufficiently well figured to be identified, and others are equally imperfect.

The figures of Australian species of *Glossopteris*, Brgt., in Dana's Geology are also of no use for comparison, as the reticulation is incorrectly and irregularly represented.

*Glossopteris* is the most common and characteristic fossil of the Damúdas. It is found in all three sub-divisions and is the unfailing evidence of the occurrence of this formation.

Bunbury's *Glossopteris musæfolia* seems from the drawing rather to belong to *Tæniopteris*, Brgt., although the author says that the veins anastomose near the stalk. This the figure, however, does not exhibit at all, and the same may be said of *Glossopteris stricta*, Bunb., from Kámthi. Tate's *Dictyopteris simplex*, (l. c.) Pl. VI, fig. 6, is a *Glossopteris* of the same group to which some of our Indian species also belong.

In one way *Glossopteris*, Brgt., may be considered evidence of a mesozoic age: if it is compared with other ferns with reticulated leaves, the most nearly allied is the Triassic and Rhætic *Sagenopteris*, Brgt., and some forms of *Glossopteris* are evidently related to this Triassic genus.

*b.* GANGAMOPTERIS, *Mc'Coy*.

In the lower group of the Damúdas (Barákars) there occur some ferns resembling *Glossopteris*, which, however, on a closer examination, show different characters; the most prominent of these is the want of the distinct midrib, which is found in the real *Glossopteris*, Brgt.; there are instead of it only three or four thicker veins starting from the base; the other veins radiating from the base towards the margin. This is a character which we find partly in *Cyclopteris*, but while in the latter genus the veins between their point of origin and the margin are divided only dichotomously, in this form from the Barákars they are reticulated, as in *Glossopteris*, Brgt. We have therefore in these leaves—

1.—Want of a distinct midrib.

2.—A venation radiating from the base towards the margin, as in *Cyclopteris*, but yet reticulated, as in *Glossopteris*.

3.—A rounder leaf than in *Glossopteris*. Similar forms have been described by Mc'Coy (Palæontol. of Victoria, Dec. II) from Australia as *Gangamopteris*, and I think I am not wrong in putting these forms from the Barákar group in the same genus.

The species I will call—

*Gangamopteris Cyclopteroides*, Fstm.

As this species occurs also in the Tálchir group, where it is almost the only fossil, I will give a diagnosis and a fuller discussion when treating of that group. A similar form* is described by Mr. Tate from the Karoo beds (Triassic) in South Africa as *Cyclopteris Jenkinsiana*, which, I think, also belongs to this genus.

The occurrence of this genus in the Barákars is very important, not for the determination of the age, but because of the connexion it shows between the lower Damúdas and the Tálchirs. It thus unites the latter with the whole Damúda group. These forms have been lately found in the Barákars of the Kurhurbari coal basin. I have also one or two fragments from Kámthi which belong to the same species.

*c.* SAGENOPTERIS, *Brgt.*

If we take *Glossopteris*, Brgt., as a single-leaved genus, with a certain venation, some other forms with several leaves coming out from the same stalk and a different venation must be separated from this genus and placed with *Sagenopteris*, Brgt. This is especially the case with the *Glossopteris acaulis*, Mc'Clell. (Rep. XIV, fig. 3), which, however,

* See Tate l. c p. 140, Tab. VI, fig.

is not correctly drawn in Mc'Clelland's Report. I have had the opportunity of seeing in our collections the original specimen and another, and have had both drawn from nature. They exhibit a very different appearance from McClelland's figure: about eight leaves pass out from a common stalk; the middle leaves seem to have been the longest; the venation is peculiar and different from that of our forms of *Glossopteris*, Brgt. I have no doubt these specimens belong to *Sagenopteris*, Brgt.; but the specific name is inappropriate, and should, I think, be changed.

### *d.* TÆNIOPTERIS, *Brgt.*

The absence of *Tæniopteris*, Brgt., in the Damúda group has been urged as one of the principal distinctions between that group and the Rájmahál, and a strong confirmation of the palæozoic age of the former. This view, however, is no longer tenable, for *Glossopteris danæoides*, Royl., figured by Royle in his work (l. c. Pl. 2-9), is really a *Tæniopteris*, Brgt. The original specimen was from the Burdwan coal-formation, that is, from the Rániganj coal-field. I have not seen the specimen, but I have no doubt about the fossil being *Tæniopteris;* the venation proves it, as the veins are distinctly *quite free at their base, and only dichotomous in their whole length.*

*The specimen from the Burdwan (Rániganj) coal-field* represented by Mc'Clelland *in his Geological Report, Pl. XV, figs. 13a, 16, under the name of Tæniopteris danæoides, Mc'Clelland, is of course also a true Tæniopteris, Brgt., and judging from the form of the frond and the distance between the veins, I am inclined to consider it the same as the species* figured by Royle. In its broad leaves and distant venation this species presents a habit corresponding with that of triassic forms of the genus. There is another specimen in the collection of the Geological Survey from the Damúda formation of Burgo in the Rájmahál hills which leads to the same conclusions as Royle's and Mc'Clelland's figures. Accidentally on the opposite side of this specimen are some fronds of *Glossopteris*, Brgt., thus proving the association of the two genera in the Damúda rocks.

Lastly, I have seen a broad-leaved true *Tæniopteris*, Brgt., from Kámthi, with very narrow veins, which resembles strongly Bunbury's *Glossopteris musæfolia*, except that the veins do not anastomose near their base (l. c. Pl. VIII, fig. 6), so that I will describe it under a different specific name. Besides this I think that *Glossopteris stricta*, Bunb. (l. c. Pl. IX, fig. 5) is also near to *Tæniopteris*, Brgt., and Sir C. Bunbury himself has figured a fragment of a *Tæniopteris* (l. c. Pl. X, fig. 2) as *Tæniopteris danæoides* (?) Mc'Cl. He may be right. It may therefore be stated without hesitation that together with *Glossopteris*, Brgt., there occur broad-leaved species of *Tæniopteris*, Brgt., with a mesozoic habitus, and that the latter afford additional evidence against the palæozoic age of the Damúda Flora.

### *e.* NEUROPTERIS, *Brgt.*

When Prof. Schimper described the fossil plants from the Vosges sandstone, he referred to the genus *Neuropteris*, Brgt., some forms which did not quite agree with the carboniferous species, although the nervature of the leaflets in these triassic forms is the same as in those from the carboniferous strata, the leaves of the former being, however, simply pinnate. Not wishing to establish a new genus, he divided the genus *Neuropteris* into two principal groups, of which one, the carboniferous type, includes species with bi- or multi-pinnate fronds; the other or triassic type comprises the forms with simply pinnate fronds which are found in the Grès bigarré (Bunter.)*

* See Schimper and Mougeot, Monogr, des plantes fossiles du grès bigarré des Vosges, 1844, p. 76.

On his Plates (l. c.) XXXVI &c. several species are figured, of which *Neuropteris grandifolia* (XXXVI, f. 1) is the largest. From the Kurhurbári coal-field our Museum received some time since a splendid specimen of the shale accompanying the coal seams. This specimen exhibited three very important genera and species, some of them represented by several specimens. One I have already mentioned, *Gangamopteris cyclopteroides*, Fstm.; another belongs to the genus now under discussion, *Neuropteris*, Brgt.

When I saw the specimen, I at once recognized several fronds of a well developed fern with single pinnæ, one being complete. At first I was astonished to see such a form; but soon I saw another fossil on the same specimen, *Voltzia*, Brgt., which left me no longer in doubt about the simply pinnate leaves. From the nervature of the leaflets and from the singly pinnate nature of the whole frond, I was sure that the specimens represented a *Neuropteris*, belonging to the group found in the Grès bigarré by Schimper, or, in short, that the specimens represent a lower triassic (Buntsandstein) *Neuropteris*, Brgt. As no palæozoic species of this character is known, I could not longer be in doubt about this, as the occurrence of the genus already mentioned (*Schizoneura*, Schimp. and Moug., also a triassic genus) and of *Voltzia*, Brgt., strongly supported my views. The nearest ally of our specimen appears to be *Neuropteris grandifolia*, Schimp. and Moug., but the Indian fern differs in the following particulars :—

*a.*—The leaflets in our specimen are wider apart.

*b.*—They begin, it is true, with entire or only slightly lobate leaflets, but the upper leaflets become larger and deeply lobate or pinnatifid.

The strong stalk both forms have in common. Our plant seems still larger than that figured by Schimper. The simply pinnate character is well seen, the lowest leaflets are nearly entire and small, the middle are the largest and nearly pinnatifid, and the uppermost again like the lower. I will call this fern—

*Neuropteris valida*, Fstm.

*Fronde simplici (pinnata), rhachide valida, striata; pinnulis imis minimis, oblongis, tota fere basi adnatis, margine sinuosis, mediis magnis, lobatis aut pinnatis, media parte basis pedicello latiusculo brevi adnatis, summis imos adæquantibus; nervis creberrimis, nervo primario basilari, vix distincto, secundariis e basi radiatim ascendentibus, dichotomis.*

Further description and discussion may be reserved until I can figure this very interesting species, which affords a strong evidence of the triassic age of the Damúda, and, as it happens, of the lower portion (Barákars).

### *f.*—ACTINOPTERIS, *Schenk.*

I had already occasion, when discussing the Kach fossil flora, to mention this peculiar fossil plant, which formerly was united with *Cyclopteris*, Brgt., Professor Göppert having described the only known species as *Cyclopteris peltata*, Göpp. On account of its relation with some living ferns, Schenk called it *Actinopteris peltata*, and showed that the horizon at which it was found was Rhætic. I found similar forms amongst the Kach fossil plants. Schimper, however, had some doubts about the nature of these fossils, and was disposed to consider them merely infiltrations of hydrated peroxide of iron. From the Rániganj coal-field we have a very well preserved specimen of a real fern, which I cannot refer to any other genus than *Actinopteris*.

I call this species —

*Actinopteris Bengalensis*, Fstm.

*Fronde orbiculariter ovata, peltata, ex foliolis singulis, segmenta formantibus composita; foliolis e media parte radiantibus, dichotome partitis, marginem versus latioribus, apice rotundatis; loco insertionis petioli medio.*

The whole frond is rather large, circularly ovate in outline, and the leaflets radiate towards the margin from the insertion of the stalk; they are very well marked by a thin layer of coal, and are dichotomous in the same way as in *Actinopteris radiata*, Link. Not a moment's doubt can exist as to this specimen being a fern.

It seems to me different from those from Rhætic strata, but is another proof of the mesozoic character of our flora. From the upper coal measures in Australia there is mentioned also "a peculiar peltate leaf," which may, perhaps, be also an *Actinopteris*, Schenk. (See Mines and Mineral Statistics of New South Wales, by John Lucas, etc., 1875, p. 129.)

Besides the ferns already mentioned, some other forms occur, which, however, need not be noticed here, as they are not of any greater importance than those I have already described. I may, however, add that *Pecopteris Lindleyana*, Royle, which has been noticed in relation with *Pecopteris australis*, Morr. (from Tasmania), belongs undoubtedly to the group of *Alethopteris Whitbyensis*, Göpp., which seems to include only mesozoic forms; still another *Pecopteris* (*Alethopteris*, Göpp.) is not uncommon, but this also exhibits a mesozoic habitus. Amongst the ferns we have therefore to note especially the following species:—

*Glossopteris indica*, Schimp., for the series.

*Gangamopteris cyclopteroides*, Fstm., for the relation of the Damúdas with the Tálchirs.

*Tæniopteris danæoides*, Mc'Clell. (Royle), and the other broad-leaved species of *Tæniopteris* from Kámthi for the mesozoic age of the Damúdas.

*Neuropteris valida*, Fstm., for the triassic (Buntsandstein) age of the Damúdas.

*Actinopteris Bengalensis*, Fstm., mesozoic form.

## C.—*CONIFERÆ.*

*Coniferæ* are very rare in the Damúdas, but a very important genus has lately been found in the Kurhurbárí coal-fields.

### *a.*—VOLTZIA.

This genus is peculiar and limited to the middle and lower Trias as Schimper states.* Brongniart, the founder of this genus, was very well acquainted with it, and described four species, all from the Grès bigarré.

On the large specimen from Kurhurbári, which I mentioned before when describing *Neuropteris valida*, Fstm., there are some branches of a coniferous plant, which, judging by

* See Schimper: Palæontologie végétale, II, p. 240.

the form of the leaves, can only belong to the genus *Voltzia*, Brgt. Our specimen agrees best with the following :—

*Voltzia acutifolia Brgt.*

1838. Brongniart : Prodromus, pp. 108, 190.
1844. Schimper et Mougeot : Monographie, etc., p. 29, Tab. XV.
1871-72. Schimper : Palæontologie végét, p. 241, Vol. II.

When I compare our species with *V. acutifolia*, Brgt., I must also add that the leaves, especially towards the end of the branches, are a little longer and broader. *Voltz. acutifolia*, Brgt., is, with *Voltz. heterophylla*, Brgt., most characteristic of the Grès Bigarré.

Besides this distinct *Voltzia* there is also a branch, with much longer and broader leaves, which I cannot identify with any known *Voltzia*, but rather with *Albertia speciosa*, Schimp. (see Schimper and Mougeot, l. c. Pl. V, f. B), which is also a well known species characteristic of Lower Trias.

This is all that need now be said about the *Coniferæ*.

The above are the most important plant remains from the Damúdas, so far as they have hitherto been determined, and no further discussion is necessary in this paper, as sufficient evidence has been brought forward for the determination of the age.

From the previous discussions I have been led to the following results:—

*a*.—*Schizoneura* is represented by the same species (*Schizoneura Gondwanensis*, Fstm.), in the Panchet group and in the Damúdas, especially in the Upper Damúdas, or Rániganj, proving that both belong to the same general epoch.

*b*.—The occurrence of *Glossopteris*, Brgt., in all the three sub-divisions of the Damúdas, besides the occurrence of triassic species (of the age of the Grès bigarré) in both the Upper and Lower Damúdas, proves that all three sub-divisions belong to the same age.

*c*.—The species *Gangamopteris cyclopteroides*, Fstm., which occurs in the Lower Damúdas (Barákars of the Kurhurbárí coal-field), and which is the prevailing fossil again in the Tálchirs, brings the latter into relation with the former, as I shall show presently.

*d*.—There is no difficulty in determining the age of the Damúdas. We have to regard only the most important fossils, *viz.*:—

*Schizoneura Gondwanensis*, Fstm. (a triassic form) ;
*Sagenopteris* (*acaulis?*) Mesozoic.
*Neuropteris valida*, Fstm. (a triassic form) ;
*Actinopteris Bengalensis*, Fstm., Mesozoic.
*Voltzia acutifolia*, Brgt. (Grès bigarré) ;

and perhaps *Albertia speciosa*, Schimp. (Grès bigarré).

All these are closely allied, and some are identical with species which hitherto are known only from lower triassic; no form is palæozoic, except *Sphenophyllum*, Brgt., which, however, shows very different characters from those of species from palæozoic rocks, therefore, considering all that I have said and determined, we are obliged, following the generally adopted palæontological laws, to consider our Damúda formation as of lower triassic age. Considering the relations of the Damúda beds and the coal-strata in Australia, only the upper portion of the latter present some analogy with these Damúda beds. In this upper portion (upper coal measures) of Australia we find fossil plants, mostly of mesozoic type, *e. g.*, *Phyllotheca australis*, *Phyll. Hookeri* (in the Newcastle coal-field, belonging to the real *Phyllotheca* type), *Vertebraria* (Damúda type), *Glossopteris* (some of them related with our Indian forms), *Tæniopteris*, broad with narrow-veins, (*Macrotæniopteris*, Schimp.), *Thinnfeldia*-like ferns, *Pecopteris odontopteroides*, Morr., a peculiar peltate leaf (which may possibly be *Actinopteris*, Schimp.), seed vessels of *Conifers* (these may, perhaps, be allied to *Araucarites Phillipsi*, Carr., or *Araucar. Kachensis*, Fstm. ?), and others, without any marine fauna. The lower portion of these Australian coal-strata presents no analogy with our Damúdas, as the latter contain none of the marine animal fossils so frequent in the lower coal-mesaures of Australia.

### V.—Fossil Flora of the Talchirs.

This is the poorest flora of all. Only a few fronds have been found, and but one or two localities are known at which fossils occur. These fossils were mentioned by Mr. Oldham* as "a large *Cyclopteris*-like leaf;" Mr. W. T. Blanford had previously recognized the nature of this fossil, and in his paper on the Ránigauj coal-field, Mem., Vol. III, p. 38, writing about the fossils from the Tálchir group, he said, "the best marked was a form intermediate between *Glossopteris* and *Cyclopteris*."

I noticed above similar fronds amongst the Damúda fossils from the Barákars. I pointed out that there are leaves with a radiating distribution of the veins, as in *Cyclopteris*, Brgt., but the veins are reticulated, as in *Glossopteris*, Brgt., and I referred them to the new genus *Gangamopteris*, Mc'Coy. I also said that these specimens from the Barákars are identical with those found in the Tálchirs: the species I called—

I.—*Gangamopteris cyclopteroides*, Fstm.

Diagnosis:

*Fronde oblongo-ovali, subobliqua, integerrima ; rhachide nulla ; nervis omnibus e basi radiantibus veluti in* Cyclopteride, *retia formantibus* (Glossopteridis *similibus*), *mediis ima parte distinctissimis.*

This diagnosis serves for the species both from the Barákars and Tálchirs.

By itself this species does not prove much; but its occurrence both in the Damúdas and Tálchirs makes it at least very probable that these two groups are very near in age, and I, for my part, look upon the Tálchirs as a lower group of the whole Damúda formation, or, in other words, as a lower horizon of the lower triassic age.

Compared with the Australian species of *Gangamopteris*, our species is most nearly related to *Gangamopteris obliqua*, Mc'Coy.†

I have thus given a short outline of the most important fossils from the lower groups of the Gondwána Series, from the Panchets, the Damúdas, and the Tálchirs, and the following general results may be deduced:—

*a.*—From the relations of the fossil plants of these three groups, it follows that they all belong to one epoch, the triassic.

* Mem. II, p. 335.

† Prodromus of the Palæontology of Victoria, Decade II, Pl. XII, figs. 2, 3, 4.

*b.*—The Panchet group has *Schizoneura Gondwanensis*, Fstm., common with the Damúdas, and whilst the other two species of the Panchets, *Pecopteris concinna*, Presl, and *Cyclopteris pachyrhachis*, Göpp., would indicate a Rhætic age, *Schizoneura Gondwanensis*, Fstm., tends to give them an older aspect, so that I class them as Keuper.

*c.*—The Damúdas have yielded important fossil plants of lower triassic age (Buntsandstein). I therefore refer all the three sub-divisions to this age, as the same fossil plants, and especially the same species of *Glossopteris*, Brgt., are found in all three.

*d.*—The Tálchirs contain a fossil plant, which has been found also in the *Barákars*, *viz.*, *Gangamopteris cyclopteroides*, Fstm., so that I do not hesitate to consider the *Tálchirs* as the lower continuation of the *Damúdas*.

We have derived, therefore, from the plants the following scheme:—

I.—JURASSIC.

| *Middle.* | *Lower.* |
|---|---|
| Kach. | Rájmahál. |
| Jabalpúr. | Golapili (near Ellore). |
| | Sripermatúr (Madras). |

II.—TRIASSIC.

| *Upper* (Keuper). | *Lower* (Buntsandstein). |
|---|---|
| Panchet group. | Damúdas— |
| | Upper (Kámthi, Ránigaṅj). |
| | Middle (Iron shales). |
| | Lower (Barákar). |
| | Tálchirs. |

NOTE ON THE GEOLOGICAL AGE OF CERTAIN GROUPS COMPRISED IN THE GONDWÁNA SERIES OF INDIA, AND ON THE EVIDENCE THEY AFFORD OF DISTINCT ZOOLOGICAL AND BOTANICAL TERRESTRIAL REGIONS IN ANCIENT EPOCHS. *By* W. T. BLANFORD, A. R. S. M., F. R. S., &c., *Geological Survey of India.*

In the preceding paper and in that published in the last number of the Records (*ante* pp. 28—42), Dr. Feistmantel has stated at length the conclusions as to the age of the different members of the great plant-bearing or Gondwána Series of India, to which a careful and exhaustive study of the fossil flora has guided him. How urgently a careful study of the plants was needed it is unnecessary to point out, and the results to Indian Geology must be most important. Guided by the abundance of particular forms, Indian Geologists had hitherto not unreasonably supposed that the Kachh (Cutch) plant-bearing beds were of the same age as those of Rájmehál, Trichinopoly, &c., for in all these localities the commonest species are two forms of *Ptilophyllum* (*Palæozamia*). In the same manner no doubt had ever arisen as to the identity of the Damúda flora with that of the Australian coal rocks, for the common types in both are species of *Glossopteris* and *Vertebraria*, which have hitherto always been supposed to be identical, whilst other forms of *Equisetaceæ* and ferns from both countries are closely allied. Whether we finally accept Dr. Feistmantel's conclusions, or not, it is impossible to conceive any researches likely to afford a greater service to Indian Geology than the accurate determination of the *homotaxis* of our different fossil floras.

At the same time it will, I think, be advisable to hesitate before accepting as proved the age assigned to the different formations on palæobotanical grounds. Dr. Feistmantel has already noticed (*ante* p. 34) the palæontological contradiction, as he very justly terms it, between the evidence derived from the animal remains in Kachh (Cutch) and that offered by the fossil plants. This contradiction is, however, much greater than would be supposed from Dr. Feistmantel's remark. The matter is so important in its bearing on the relations of Indian rocks that it will be well briefly to recapitulate the history of the examination of the Kachh beds by the Survey.

From a very cursory examination which I made in 1863 of a small portion of the province,* I was led to believe that the plant-bearing beds in Kachh, as a whole, rest upon the series of rocks with marine fossils of jurassic age, but that in some cases marine beds are intercalated with the upper plant-bearing group, and I pointed out that if they are not interstratified, certain fossiliferous bands in the Chárwar range south of Bhooj must have been brought up by a fault. Messrs. Wynne and Fedden surveyed Kachh in 1867-68-69,† the jurassic rocks being chiefly examined by Mr. Wynne, who found that a fault really exists, bringing up the rocks of the Chárwar range; consequently the principal grounds on which my belief in the interstratification of the marine and plant-bearing strata were founded proved untenable. Some information I had received as to the occurrence of marine fossils near Bhooj‡ appears also to have been incorrect. At the same time, the conclusion at which I had arrived, that both marine and fresh-water beds belong to one series, and that the two pass into each other, was entirely confirmed by Mr. Wynne. He also found in some places unquestionable intercalation of the plant-beds with strata containing marine fossils.§

The Cephalopoda collected by Messrs. Wynne and Fedden were examined by Dr. Waagen,|| who found that those from different localities showed the existence of several distinct groups of jurassic strata, ranging from Lower Oolite (Bathonian) to Uppermost Oolite (Portlandian and Tithonian). Dr. Stoliczka went to Kachh in 1872, and spent several months in examining the rocks. He ascertained that four separate groups of jurassic beds, distinguished by well-marked mineralogical and palæontological characters, can be traced *throughout the area occupied by the rocks of Oolitic age. These groups he called—*

| | | |
|---|---|---|
| 1. | *UMIA (Oomia)* ... ... ... | *Tithonian and Portlandian.* |
| 2. | KATROL ... ... ... | *Kimmeridge and Upper Oxford.* |
| 3. | CHARÍ (Charee) ... ... | Lower Oxford and Kelloway (Callovian). |
| 4. | PACHAM (Patchum) ... ... | Bath Oolite. |

Dr. Stoliczka's names were adopted in Dr. Waagen's account of the Jurassic Cephalopoda of Kachh,¶ and the groups referred to the abovementioned European sub-divisions of the jurassic series.

No account of Dr. Stoliczka's work in Kachh has ever been published. Shortly after returning he left with the mission for Turkestan, and he died on the return journey. The note books used by him in Kachh are amongst the survey records; they contain a very full account of his exploration of the province, and after reading them through, I think there

* Mem. Geol. Surv., India, VI, p. 17.
† Mem. Geol. Surv., India, IX, pp. 1—289.
‡ Mem. Geol. Surv., India, VI, p. 21.
§ l. c., pp. 51, 210, 213, 215, 216.
|| Rec., Geol. Surv., India, IV, p. 89.
¶ Pal. Indica, Ser. IX, Introduction.

can be no question of the conclusions at which he arrived regarding the relations of the plant-bearing beds to the marine strata. His views were precisely the same as Mr. Wynne's and my own; he determined that the plant-beds form the highest member of the jurassic series, that they pass down into the beds with marine fossils of the Umia group, and that in some places bands of these marine fossils, especially *Trigonia Smeei* and a *Trigonia,* closely allied to the cretaceous *T. tuberculifera** of Southern India, are intercalated in the plant-bearing group. He consequently classed both the plant-bearing beds and the Umia marine beds in one group. Moreover, he found in one place, resting upon the plant-beds, a band containing cretaceous cephalopoda of Upper Neocomian (Aptian) age.† It is difficult to ascertain from Dr. Stoliczka's field notes whether he considered these cretaceous rocks conformable to the Umia beds, or not, but he certainly on his return spoke of this Umia group as of Wealden age.

I may add at once that of the localities mentioned by Dr. Feistmantel, *viz.*, Kukurbit, Trombow, Bhoojooree, Doodaee, Loharia, and Goonaree,‡ all, except the last named, are in the beds forming the upper part of the Umia group, and there is no important difference in the horizon. Goonaree is rather lower in position according to Dr. Stoliczka's map, being in the lower portion of the Umia group and associated with the marine beds, but not one of the localities is below all the beds with upper oolitic fossils. From Nurha,§ the only locality in Kachh belonging to the Katrol group at which remains of plants have been obtained, the specimens, which have just been found, appear to belong to species found also in the Umia group.

It is important to insist upon these facts in order to prevent mistakes. It should be distinctly understood that *the rocks in Kachh (Cutch) with a lower oolitic flora, and containing several species of plants identical with those found in the Lower Oolites of Yorkshire, rest upon marine strata containing Portland and Tithonian Cephalopoda, and are capped by beds with Upper Neocomian (Aptian) Ammonites;* that occasionally the marine strata with upper oolitic fossils are interstratified with the plant-beds; and that the geological position of the Kachh plant-beds has been determined by careful and repeated examination by three different geologists, all of whom agree in their conclusions.

I do not see any probability of error in the determinations of the marine fossils. Dr. Waagen, whose knowledge of Jurassic Cephalopoda is probably equal to that of any Palæontologist living, insists particularly on the remarkable parallelism of the different groups which make up the jurassic series in Europe and India. The remainder of the fauna has not received the same careful examination and comparison as the Cephalopoda, but I believe I am justified in saying that both Dr. Stoliczka and Dr. Waagen considered that the evidence afforded by it coincided with that furnished by the Cephalopodous Mollusca. Dr. Waagen especially states‖ that in the Umia beds of nine species of Cephalopoda,

* Pal. Indica, Ser. VI, 3, p. 315, Pl. XV, figs. 10–12.

† Pal. Indica, Ser. IX, p. 245.

‡ It may be useful to point out where these places are; they are small villages not marked on most maps, and not easy to identify—

Gooneri (Goonaree of map) is in north-western Kachh (Cutch), about six miles east south-east of Lukput

Thrombow, six miles north-east of Bhooj.

Kukurbit, twenty miles west by a little north of Bhooj.

Bhoojooree, five miles east-south-east of Bhooj.

Doodaee, about thirty miles east of Bhooj.

Loharia, seventeen miles south-east of Bhooj, and south of the Katrol range

The spelling is that of the map in the Memoirs, Vol. IX.

§ Mem. Geol. Surv., India, IX, p. 213.

‖ Pal. Ind., Ser. IX, Vol. I. Kachh Cephalopoda, pp. 225 and 233.

four are identical with European forms found either in the Tithonian beds of Southern Europe, or the Portland Oolite of England and France, and he adds that this proportion of forms common to the two regions will increase greatly when the other classes of mollusca are described, 'as many of the *Pelecypoda* of this bed seem to be identical with species from the Portland stone,' and elsewhere he especially mentions the abundance of *Trigoniæ* of the type of *T. gibbosa.*

This is not written with a view of impugning Dr. Feistmantel's conclusions. These will be given to the public in full in the 'Palæontologia Indica,' and I have no doubt are as accurate and trustworthy as Dr. Waagen's. But it is important to call attention to the exact terms of the contradiction between the marine and terrestrial forms of the Kachh Oolites, because it shows that one or the other is misleading when applied to the determination of geological age. As the marine fossils are much more numerous, and probably afford a much less imperfect representation of the life of the period, as they occur in a larger sequence of rocks and have attracted much more attention, and as they are preserved in a manner which, I believe, it is generally considered, enables their affinities to be determined with greater accuracy, it will, I think, be admitted by most palæontologists that we must accept the conclusions derived from them. The deduction is inevitable, that the comparison of the remains of plants leads in this case to results, as regards geological age, which are not accurate, and that other identifications on similar data must be received with great caution.

It necessarily follows that although the homotaxis of the Rájmehál flora be liassic, and that of the Panchets and Damúdas triassic, we can only accept this homotaxis as an approximation to the actual geological age of the formations.

Between the Upper Gondwána rocks to which the Rájmehál and Jabalpúrs belong, and the Lower Gondwána series comprising the Panchets, Damúdas, and Tálchirs, there is a great break in the forms of life. Cycads abound in the former, but have not hitherto been found in the latter, whilst the lower series is characterized by the abundance of equisetaceous plants. The only genera known to be common to the two, are ferns of considerable range in time. It follows as a matter of course that no arguments as to the age of the Lower Gondwána rocks can be drawn from the upper part of the series.

The evidence which Dr. Feistmantel has shown to exist in favour of ascribing a Triassic age to the Panchets, Damúdas, and Tálchirs is undoubtedly of great importance; but I feel some doubts as to whether it is conclusive, and although it is with great hesitation that I venture to express a different opinion on a subject on which Dr. Feistmantel's knowledge of palæobotany enables him to form a more accurate opinion than I can offer, I still think that if the evidence of plants alone be employed to determine the age of the Indian rocks, the relations between the Indian and Australian coal-measures must be taken into consideration in estimating the homotaxis of the Indian formations.*

It is also only fair to point out that the main arguments for the triassic age of the Damúdas are derived from the occurrence of three plants which were only discovered this year. Even admitting, for the sake of argument, that the evidence at present justifies the reference of the Damúda beds to the Trias, it by no means follows that the flora known sixteen years, or even two years ago, was sufficient to warrant the same conclusion, and I believe Dr. Oldham was quite right in 1860,† and that my brother, Mr. H. F. Blanford, was equally justified‡ in 1874, in assigning a palæozoic age to the Damúda formation on the evidence of the plant remains alone. The Panchet beds have always, since they were first defined, been considered as probably Triassic.

* Dr. Feistmantel's argument, that because the marine forms which determine the age of the Australian rocks are absent in India, the evidence of the plant remains becomes of less value, is quite true, but it is just as applicable to the Damúda plants common to the trias of Europe as to those found also in Australia.

† Mem. Geol. Surv of India, II, p 333, &c

‡ Quart Journ. Geol. Soc., 1875, pp 528, 531, &c

Of course the first and most important question is, whether the age of the Australian coal-measures is definitely settled. It is not surprising that the evidence should be received with some distrust when it is found that ever since they were first described, one group of observers, headed by Professor McCoy, has persistently declared that the coal-beds are of jurassic age, whilst another group, comprising especially the Rev. Mr. Clarke, Professor Jukes, and Mr. Daintree, have contended that they are palæozoic. But there is an important difference between the two classes. The geologists have all examined the rocks *in situ*, and have ascertained that the plant-bearing beds are interstratified with marine bands containing *Brachiopoda* and other fossils admitted to be of carboniferous age by all palæontologists. Of the palæo-botanists, McCoy, Morris, deZigno, Carruthers, Schimper, and others, who have contended for the jurassic age of the Australian rocks, not one has ever examined the beds, and their opinions cannot consequently be of any weight, as opposed to the views of the geologists. Mr. Clarke has published two sections of coal-pits,* in which coal-seams and shales with *Glossopteris*, *Phyllotheca*, and *Noeggerathia* (*? Schizoneura*) are shown to have been reached after passing through beds containing *Spirifer*, *Fenestella*, *Conularia*, *Orthoceras*, and other fossils of admitted carboniferous age. Mr. Daintree also has published a section† showing beds with *Productus* and *Spirifer* resting upon coal-seams with *Glossopteris*. Unless the palæo-botanists can prove that Clarke's and Daintree's sections are incorrect, the question must be decided against the mesozoic age of the *Glossopteris* beds.

The succession of formations in the coal-fields of New South Wales is said to be the following ‡:—

1. Wianamatta beds ... } No *Glossopteris* mentioned in the lists of fossils.
2. Hawkesbury beds ... }
3. Upper coal seams of Newcastle with *Glossopteris*, *Vertebraria*, &c.
4. Lower coal-seams of Newcastle with *Glossopteris*, *Phyllotheca*, *Noeggerathia*, (*? Schizoneura*) &c. With these and above the plant-bearing beds are bands with marine carboniferous fossils.
5. Marine carboniferous rocks.
6. Lower carboniferous or Devonian beds with *Lepidodendron nothum*, Unger, &c.

The Wianamatta and Hawkesbury beds, so far as is known, contain no plants common to any of the Indian rocks. They are now classed as older mesozoic. They are said to be connected with the beds beneath them, No. 3, by the presence of a plant, *Pecopteris odontopteroides*, Morris, in abundance in both, just as the Panchets in India are connected with the upper sub-division of the Damúdas by the occurrence in both of the same species of *Schizoneura*. In the same manner the floras of Nos. 3 and 4 appear to be connected by the presence of *Glossopteris Browniana* in both, although, from specimens which Dr. Feistmantel has showed to me, there appears to be a considerable distinction in the flora. Until the Australian plant remains are subjected to a thorough revision, it will, perhaps, be unwise to consider too much as proved; but so far as the evidence goes, it appears that all the Australian plant-bearing rocks of Australia are connected by species of plants passing in each case from one to the other, precisely as Dr. Feistmantel has shown to be the case with the rocks of the lower Gondwána series in India, and if on the strength of the evidence we are justified in assigning the Panchets, Damúdas, and Tálchirs to the Trias, because the two former contain triassic plants, and the Tálchirs contain one plant, also found in the lower Damúdas,

* Transactions, Royal Society of Victoria, Vol. VI, 1861, and Remarks on the Sedimentary Formations of New South Wales, 3rd edition, 1875. p. 61; see also Quart. Journ. Geol. Soc., XVII, 1861, p. 354.

† Quart. Journ. Geol. Soc., XXVIII, 1872, p. 286.

‡ Quart. Journ. Geol. Soc., XVII, 1861, pp. 358, 360; XXVIII, 1872, pp 283, 286, 355, &c. Clarke, Sedimentary Formations of New South Wales, pp. 15, &c.

we should equally be obliged to relegate the whole of the Australian coal-measures below the Hawkesbury group to the Carboniferous, because they contain at least one species of plant throughout, and their lower sub-division is interstratified with beds containing marine carboniferous fossils.

With one or the other of these Australian coal-beds, No. 3 or No. 4 of the preceding section, the following plants of the Damúda groups are common :—

*Glossopteris*, two or three species identical.
*Gangamopteris** (the genus only).
*Vertebraria*, one species identical.
*Pecopteris* (*Alethopteris*), one species probably identical.
*Schizoneura* (*Zeugophyllites*.)

We have thus five genera and four or five species common, without counting the *Equisetaceæ* (*Phyllotheca*, &c.), which appear somewhat doubtful. With the triassic rocks of Europe, Dr. Feistmantel has shown that the following Damúda forms are common :—

*Voltzia*, one species identical,
*Albertia ?* ditto ?
*Actinopteris*, the genus only, the species shewing affinity,
*Sagenopteris*, ditto, ditto,
*Neuropteris*, ditto, ditto,
*Schizoneura*, ditto, ditto,

or six genera and one or, perhaps, two species. It is quite true, as Dr. Feistmantel has shown, that *Pecopteris* (*Alethopteris*) *Lindleyana* of the Damúdas has nearly as close affinities to certain jurassic forms in Europe as to *P. Australis ;* but, on the other hand, an equisetaceous plant occurring near Nágpúr† was described by Sir C. Bunbury under the name of *Phyllotheca Indica* from a good series of specimens, and considered closely allied to some Australian forms.

On the whole, it appears to be a reasonable conclusion that the evidence which connects the Damúda formation with the Australian carboniferous rocks is about equal to that which tends to show their relations with the Trias of Europe, the only distinction of importance being that the evidence of connection with the Australian beds is so abundant, and the plants which are common to the Trias are (with the exception of *Schizoneura*) so rare, that the latter have hitherto been overlooked.

The evidence afforded by the few animal remains hitherto procured from the Gondwána series is nearly as confusing as that of the plants. From the Kota and Maleri beds now shown‡ to be identical, and to belong to the Upper Gondwána series, we have *Ceratodus*, which in Europe is Triassic or Liassic, but which has been found living in Australia; *Hyperodapedon*, Triassic in Europe, but allied to the living New Zealand genus *Hatteria ;* and certain early mesozoic forms of *Crocodilia*, together with fish (*Lepidotus* and *Echmodus*) with liassic affinities, and *Estheria*, which is insufficient

* The specimens described by McCoy (Prod. Palæont. Victoria, Decade II, Pls. XII & XIII) are said by their describer to be from the upper coal-bearing strata of Victoria, the position of which is uncertain, but Dr. Feistmantel has detected one species in the beds from beneath the carboniferous marine beds of Newcastle, N. S. Wales.

† Quar. Journ. Geol. Soc., XVII, p. 335.

‡ See the following paper by Mr. Hughes.

for the determination of age. In the Panchet group of the Lower Gondwána series we have *Dicynodon* showing an affinity for South African strata, other reptiles from which have just been shown by Professor Owen* to be allied to Permian forms found in Russia. The other known Panchet *Vertebrata* are *Labyrinthodonts* and a *Thecodont Saurian*, which, according to Professor Huxley, might be either lower mesozoic or upper palæozoic. Besides these there are the ubiquitous *Estheriæ*. From the Damúda formation (including the Kánthi of Mángali) one *Labyrinthodont* (*Brachyops laticeps*) has been described, the affinities of which appear to be uncertain, an *Archegosaurus*, hitherto only imperfectly examined, and *Estheriæ*. The whole evidence, so far as it goes, both of animals and plants, tends to connect the whole of the Gondwána series with formations ranging from the Upper Palæozoic to the Lower Jurassic.

It must be remembered that the affinities between the plants of the Australian coal-bearing rocks and those of the jurassic beds of Europe are unmistakeable. They have been pointed out by all palæo-botanists, and they extend to some of the plants in the beds interstratified with the carboniferous marine strata.

It would have been useless to recapitulate all these facts, most of which are well known, and none of which are new, did they not lead to a conclusion which appears to me of the highest importance with reference to the ancient distribution of animals and plants.

In the present distribution of the animal kingdom, there is much greater uniformity throughout the globe in the marine than there is in the terrestrial fauna. The former varies chiefly with the depth beneath the sea, and, amongst the shallow water and coast forms, with climate. A collection of Mollusca or Echinodermata (and these are our principal guides in palæontological classification) from the Atlantic, the Pacific, and the Indian Oceans, all taken within the tropics, would afford but few examples of generic distinction. A collection of terrestrial *vertebrata* or *invertebrata* from Tropical America, Northern Australia, Malacca and Africa, would differ from each other, not merely in genera, but, in many instances, in families. The plants from these different tropical lands would also exhibit marked generic distinctions, and whilst many of the American plants would show affinities with the miocene forms found in Europe, numerous representatives would be found, amongst Australian animals and plants, of forms which, in Europe, were typical of mesozoic strata.†

In the evidence now recapitulated, that the plants which existed in Australia, whilst carboniferous forms inhabited the seas, were allied to species and genera of the jurassic flora of Europe, that some of these same forms of carboniferous age in Australia co-existed in India with species found also in the triassic rocks of Europe, and that plants of the lower oolite of England still existed in India, whilst the surrounding seas nourished uppermost oolitic forms, we have convincing proof that the land faunas and floras of palæozoic and mesozoic times differed from each other in various parts of the globe, at least as much as they do in the present day. In short, the conclusions to which we are, I think, brought by a consideration of the evidence are—

1*st*.—That the faunas and floras of distant lands varied in palæozoic and mesozoic times, as they do at the present day, far more than the fauna of the seas; in short, that there were distinct terrestrial zoological and botanical provinces.

2*nd*.—That evidence, founded upon fossil plants, of the age of rocks in distant regions, must be received with great caution, and that such evidence is certainly in some cases opposed to that furnished by the marine fauna.

* Geological Society of London: Meeting of May 24th, 1876. Only an abstract of the paper has hitherto reached India.

† It would take up too much space to go into details. *Zamia* and certain *Proteaceæ* amongst plants, *Ceratodus* and the *Marsupialia* amongst animals, are sufficient to establish the general fact.

ON THE RELATIONS OF THE FOSSILIFEROUS STRATA AT MALÉRI AND KÓTÁ, NEAR SIRONCHA, CENTRAL PROVINCES, *by* TH. W. H. HUGHES, A.R.S.M., F.G.S., *Geological Survey of India.*

The fossiliferous strata alluded to in this paper have already been brought to notice directly in the Quarterly Journal of the Geological Society of London,* and incidentally in our own Memoirs,† and various other publications, but hitherto only speculative suggestions as to their mutual relations have resulted, the essential element of stratigraphical evidence having been wanting to complete the data for practical discussion.

This year, however, in the course of a special tour in which I accompanied Mr. King, Deputy Superintendent of the Survey for Madras, we were able to visit Kótá and Maléri, and to trace the extension of the more prominent beds of the one locality into connection with those of the other, thus supplying the needed evidence.

The result we have come to is, that the Kótá and Maléri beds must be classed together, or, at all events, are members of the same series, and that they are younger than the Kámthi, or Kámthi-Damúda series.

The most interesting result of our palæontological researches in the same district was the discovery by Mr. King, in strata below the beds at Kótá, of a *Palissya* which Dr. Feistmantel has identified as a specific representative of one in the Rájmahál series (*Palissya conferta*); while in beds associated with the fossiliferous strata at Maléri, I detected another *Palissya*, referable to a species found in the Jabalpúr group, and also the *Araucarites* of the Kach plant-beds.

The fauna already known from Kótá and Maléri is represented by relics of *Lepidotus, Œchmodus,* and *Ceratodus,* with the crocodilian genus *Parasuchus, Hyperodapedon,* &c., some of which indicate a Triassic age, whilst none are represented by allied forms in European strata at more recent period than the Liassic.

We thus have associated in the same group plants of our Indian Jabalpúr, Kach, and Rájmahál groups, and animals, which, if judged by European analogy, are certainly not younger than the age of the Lias.

Dr. Feistmantel has recently endeavoured to show that the flora of the Jabalpúr, Kach and Rájmahál groups proves them to be older than the age usually ascribed to them, a view which our discovery tends to strengthen.

NOTES ON THE FOSSIL MAMMALIAN FAUNÆ OF INDIA AND BURMA, *by* R. LYDEKKER, B.A., *Geological Survey of India.*

Introduction.

The present short paper is intended to appear as a kind of preface to full descriptions of several new species of fossil mammalia which have lately been discovered in the tertiary strata of India and Burma, chiefly by Members of the Geological Survey of India. These descriptions will appear in the "Palæontologia Indica," according to the opportunities of publication.

Formations.

The formations and districts from which the remains of mammalia have hitherto been discovered in India and Burma are shown in the following lists; these I have arranged according to that which seems to me to be their most probable succession in time; several

* VII, p. 272; VIII, p. 230; IX, p. 351; XVII, p. 349; XX, pp. 117, 280, &c.
† II, p. 335; III, p. 202; IX, p. 33.

**faunæ, such as those of the old alluvium of the Ganges and Jamna, of the gravels of the Nerbudda Valley, and of certain beds of the Deccan, are grouped provisionally together, as they evidently belong to (geologically speaking) the same epoch; at the same time I would observe that these beds are nowhere found in direct apposition, and that, therefore, there may be considerable differences in their age. It is also to be borne in mind that many of these formations containing distinct groups of animals may really be contemporaneous, the difference in their faunæ being caused by physical conditions. After the names of certain genera and species in the succeeding lists, my own name is added; these genera and species are new to the fossil Indian fauna, and full descriptions will subsequently appear in the "Palæontologia Indica."**

The following list comprises the known mammaliferous beds of India:—

*Indian Mammaliferous Series.*

| | | |
|---|---|---|
| | Modern alluvia of rivers and plains, containing human remains and bones of living Mammalia. | Recent. |
| | *a.*—Old alluvium of Jamna and Ganges.<br>*b.*—Older gravels of Nerbudda and Godávarí.<br>*c.*—Gravels of the Deccan. | Post Pliocene or Newer Pliocene. |
| SIWALIK. | *d.*—Upper Siwalik conglomerates and clays.<br>Siwaliks of Falconer. (Pal. Mem. *passim.*)<br>Mammaliferous sandstones and clays of Jamu. Medlicott: Rec. Geol. Surv., Ind., Vol. IX. pt. 2.<br>Mammaliferous sandstones and clays of Potwar and Kohat districts: (Wynne: Mem. Geol. Surv., Ind., Vol. X, pt. 2.)<br>Marine mammaliferous sandstones of Chittagong and Sylhet<br>Siwaliks (?) of Tibet.<br>Manchhar beds of Sind (and Kach ?)<br>Mammaliferous beds of Pegu and Irawádí River.<br>Mammaliferous beds of Perim Island. | Pliocene. |
| | Beds at Kushalghar (forty miles south of Attock) | ... Upper Miocene (?) |
| | Náhan beds of Bakrálá Range ... ... | ... Upper Miocene (?) |
| SUBATHU ... | Nummulitic beds of Salt Range and Fatehjang | ... Miocene. |

Commencing with the uppermost beds in this list, it will be seen that I have grouped three (*a, b, c,*) together; the two first are placed together on the authority of Dr. Falconer, who grouped the older alluvia of the Jamna with the older gravels of the Nerbudda valley, on account of the similarity of their faunæ (Pal. Mem., vol. II, p. 580.)—The Upper Siwalik group I have also placed near these beds (see *infra*), on account of the distinctness of its few mammals from those of the underlying beds: at the same time it must be observed that these uppermost beds are conformable to the underlying series, while they are capped by unconformable strata, which may be contemporaneous with part of the river alluvia: it would, perhaps, be best, therefore, to regard these Upper Siwaliks as "transition beds" between the true Siwaliks and the Nerbudda and Jamna series.

The following list of genera and species is given by Falconer (Pal. Mem., vol. II, p. 642) from the older alluvia of the Jamna:—

| | |
|---|---|
| Euelephas namadicus, Falc. | Bubalus palæindicus Falc. |
| Tetraprotodon palæindicus Falc. | Sus (sp.) |
| Equus (sp.) | Bos (sp.) |
| Cervus (sp.) | Antilope (sp.) |

In the Indian Museum* we have also specimens of *Mus* and *Semnopitheous* from the same deposits. The whole of the genera in the above list are still living in India with the exception of *Tetraprotodon*, which is now confined to Africa: all the genera (and species at present determined) are also found in the Nerbudda deposits. The mammalian fauna of the Nerbudda and Godávarí deposits presents a somewhat more copious list than the foregoing: many of the species have been figured by Falconer (see "Fauna Antiqua Sivalensis" and "Palæontological Memoirs"), but a few new species are contained in the collection of the Indian Museum. The following is the list from these formations:—

BIMANA.

Man. (stone weapons.)

PROBOSCIDIA.

| | |
|---|---|
| Elephas namadicus, Falc. ... | Stegodon insignis, Falc. |

PERISSODACTYLA.

| | |
|---|---|
| Rhinoceros namadicus, Falc. ... | Equus namadicus, Falc. |

ARTIODACTYLA.

| | |
|---|---|
| Hexaprotodon namadicus ... | Bubalus palæindicus, Falc. |
| Tetraprotodon namadicus ... | Bos namadicus, Falc. |
| Cervus namadicus, Falc. | |

CARNIVORA.

| | |
|---|---|
| Felis (sp. nov. Indian Museum) ... | Ursus namadicus, Falc. |

RODENTIA.

Mus (sp. nov. Indian Museum).

The topmost Siwalik clay and conglomerates near Bubhor (see Mr. Medlicott's paper, Rec. Geological Survey, India, vol. IX, pt. 2, p. 57) have yielded to Mr. Theobald's careful search two species of Mammals, *viz.*, *Bubalus palæindicus* and *Camelus sivalensis*. As the first of these species is unknown amongst the subjacent Siwalik Fauna, and as the second is an essentially modern form, I have chosen to group these uppermost Siwaliks with the Nerbudda beds rather than with those lying below them. Mr. Medlicott, however, is rather inclined to doubt this view.

Living genera.

It will be observed that in the above lists, the whole of the genera, with the exception of *Hexaprotodon* and *Stegodon* (which are really only sub-genera), are still living on the globe, and among the living genera, with the exception of Hippopotamus, the whole number are still living in India. None of the fossil species have, hitherto, been satisfactorily identified with living forms; one species of deer is, however, very closely allied to the living Indian *Rucervus* (as I shall show in a subsequent paper); and the *Bubalus palæindicus* (as far as craniological characters go) is scarcely separable from the *Bubalus arni* of India. The presence of a true taurine ox (*Bos namadicus*) in these beds marks the distinctness of this fauna from that of modern India, but, at the same time, such a highly specialized form confirms the very recent age of these formations.

Certain species of Ruminants, such as *Bos Falconeri* and *Cervulus styloceras* described by Mr. Theobald from the Nerbudda valley (Mem. Geol. Surv., India, vol. II, p. 279), *are founded on bones of Bos namadicus and Rucervus.*

* *Bones figured in the Journal of the Asiatic Society, Bengal (vol. II. p. 35), as human from these beds, were subsequently shown by Falconer to belong to other mammalia.*

Deccan beds.

The last fomation which I have provisionally placed in this newer group consists of certain gravels and clays from the Deccan, containing Mammalian remains, some of which have been described by Mr. Foote (Pal. Ind., Ser. X, Vol. II).

The fauna at present only comprises three genera, two of which are only known by fragments, and cannot be specifically determined. These are—

Rhinoceros deccanensis (Foote).
Bos (sp). Equus (sp).

*Mastodon pandionis*, Lartet, has also been described by Falconer from superficial beds in the Deccan ("Palæontological Memoirs," Vol. I, p. 124).

These gravels being superficial and undisturbed, point to the comparatively modern age of the beds: the bones, too, are in an extremely friable and rotten condition, which would induce one to think that had they been buried for long geological periods in this pervious soil, they would have completely perished. At the same time, the molars of the species of Rhinoceros are so different from those of any living or fossil Indian species, that I cannot help thinking these beds may be older than those of the Nerbudda valley, or, at any rate, that the Rhinoceros is one of the last survivors of an older fauna.

The very peculiar and prominent "cingulum" on the premolars of this species indicates considerable relationship with the older *Acerotherium* and *Palæotherium*. If Falconer is right in identifying the Deccan *Mastodon* with *M. pandionis*, this is the only instance of a fossil Indian Mammal being identical with a European species.

Pliocene.

The different groups of strata included under this head comprise those beds which have produced the greatest number of fossil Mammalia: I have included under the head of Pliocene-Siwalik nearly the whole of the Mammaliferous beds of the Sub-Himalayan region (with the exception of the topmost beds noted above), because we have hitherto found no distinction in the Mammalian Fauna of the different beds. Few identifiable Mammalian fossils have yet been discovered from the Náhan beds of Mr. Medlicott (Mem. Geol. Surv., India, Vol. III, p. 101), nor from what appear to be their corresponding beds in the Jamú and Potwar country (Rec. Geol. Surv., India, Vol. IX, pt. 2) described by Mr. Medlicott. The main exception to this are certain fossils, to be subsequently noticed, coming from the south of Attock.

Mr. Wynne (Mem. Geol. Surv., India, Vol. X, pt. ii, p. 24) has proposed to identify the grey sandstone and brown-clay series of the Potwar and Kohát districts with the Náhans of Mr. Medlicott: this, I believe, partly arose from a mistaken conception of the geological age of certain fossils collected by Mr. Theobald in the Kángra and Jamú districts: these fossils were all collected from Siwalik and not from Náhun beds, and as they agree specifically with those from Mr. Wynne's grey and brown beds, I have no hesitation in placing these, on palæontological grounds only, as of Siwalik age: Mr. Medlicott agrees with this view (Rec. Geol. Surv., India, Vol. IX, pt. 2, p. 56).

The whole of the Mammalian fossils (with the exception of those from near Attock), described by the late Dr. Falconer, were, I have not the least doubt, obtained from the typical Siwalik horizon of Mr. Medlicott; and there is, therefore, no ground for the suggestion which has been made, that Dr. Falconer erred in not making a distinction between Siwalik and Náhun Mammalian fossils. The divisions in the Siwalik strata, founded on lithological characters only, I have not noticed, as they do not, as far as we know at present, contain distinctive groups of Mammalia.

The following is the list of Fossil Mammalia at present known to me from the Sub-Himalayan Siwaliks:—

PROBOSCIDIA.

| | |
|---|---|
| Stegodon insignis, Falc. | Euelephas hysudricus, Falc. |
| Stegodon bombifrons, Falc. | Mastodon latidens, Falc. |
| Stegodon ganesa, Falc. | Mastodon sivalensis, Falc. |
| Loxodon planifrons, Falc. | |

PERISSODACTYLA.

| | |
|---|---|
| Rhinoceros platyrhinus, Falc. | Equus sivalensis, Falc. |
| Rhinoceros sivalensis, Falc. | Equus palæonus, Falc. |
| Rhinoceros palæindicus, Falc. | Hippotherium antilopinum, Falc. |
| Acerotherium perimense, Falc. | Listriodon sp. mihi. |

ARTIODACTYLA,—Suina.

| | |
|---|---|
| Hexaprotodon sivalensis, Falc. | Sus giganteus, Falc. |
| Merycopotamus dissimilis, Falc. | Sus hysudricus, Falc. |
| Tetraconodon magnum, Falc. et mihi. | Hippohyus sivalensis, Falc. |

ARTIODACTYLA—Pecora.

| | |
|---|---|
| Chalicotherium sivalense, Falc. | Bison sivalensis, Falc. |
| Camelus sivalensis, Falc. | Hemibos triquetriceros, Falc. |
| Sivatherium giganteum, Falc. | Amphibos acuticornis, Falc. |
| Camelopardalis sivalensis, Falc. | Peribos occipitalis, Falc. et mihi. |
| Dorcatherium, 2, sp. mihi. | Bos, sp. var. Indian Museum. |
| Capra, sp. Brit. Mus. | Cervus, sp. var. Indian Museum. |

CARNIVORA.

| | |
|---|---|
| Felis cristata, Falc. | Hyænarctos sivalensis, Falc. |
| Felis palæotigris, Falc. | Amphicyon, sp. mihi, Indian Museum. |
| Drepanodon sivalense, Falc. | Ursitaxus sivalensis, Falc. |
| Hyæna sivalensis, Falc. | Lutra palæindica, Falc. |
| Canis, sp. Brit. and Indian Museum. | Enhydriodon ferox, Falc. |

RODENTIA.

Hystrix, sp. Falc. Mus sp. Falc. Typhlodon sp. non-desc, Falc.

QUADRUMANA.

Semnopithecus Sub-Himalayanus, Meyer: and Macacus.

Several species mentioned in the manuscript notes of the late Dr. Falconer, but never described, and of which the original specimens are now unknown, have been omitted from the above list, as it is quite impossible to identify them. *Camelopardalis affinis* of Falconer has also been omitted, because the species appears to me to have been founded on a mistake. (See Appendix.)

Referring to the table of formations given above, we find the next on the list to be certain beds at Chittagong; these beds I have never seen, nor am I aware that they have been described: they are inserted here on the evidence of a small collection of fossils from the above locality in the Indian Museum. These fossils are imbedded in a coarse green sand matrix, and comprise two or three genera of marine shells, with teeth of *Lamna,* and two Mammalian molars: one of the latter I have identified with *Sus hysudricus* of the Siwaliks; the other is the molar of a species of *Cervus,* apparently new; of course till more specimens are obtained from this district, it would be rash to speculate as to the age of the beds, though they may very probably be Siwalik.

The next formation on the list is the Mammaliferous series of Pegu and the Irawadi river: fossils from these beds have been described and figured by Dr. Falconer ("Fauna Ant. Sival." and "Pal. Mem."), and by Mr. Clift (Trans. Geol. Soc., London, 2nd series, vol. 4); several new species of Mammals from this district are contained in the collection of the Indian Museum, obtained by Mr. W. T. Blanford and Mr. W. Theobald. The following list contains only those species of which the locality is certain:—

PROBOSCIDIA.

Stegodon Cliftii, Falc.
Mastodon sivalensis, Falc.
Mastodon latidens, Falc.

PERISSODACTYLA.

Rhinoceros n. sp. mihi, Ind. Mus.
Acerotherium perimense, Falc.
Equus sp. Ind. Mus.
Tapirus, Clift.

ARTIODACTYLA.

Hexaprotodon iravadicum, Falc.
Merycopotamus dissimilis, Falc.
Vishnutherium iravadicum n. gen. mihi.
Bos. sp. Ind. Mus.
Cervus sp. Ind. Mus.

CARNIVORA.

Ursus sp. Indian Museum.

The fauna of the (probably) Siwalik strata of the Niti Pass and Tibet is only known from a few fragments of bone described by Dr. Falconer ("Pal. Mem.," Vol. I, p. 175), and from certain fossils collected by General Strachey (Quar. Journ. Geol. Soc.. London, Vol. VII, p. 292); these comprise remains of a species of Rhinoceros, and of a ruminant allied to *Ovis* or *Capra*.

The mammaliferous strata of Sind, with which I should be disposed to group those of Kach, have been recently described by Mr. W. T. Blanford (Rec. Geol. Surv., India, Vol. IX, pt. 1) under the name of Manchhar beds, which he correlates with the Sub-Himalayan Siwaliks; the only genera which I can at present identify among the numerous fragments of bones collected by Mr. Fedden from these deposits are the following:—

PROBOSCIDIA.

Mastodon latidens, Falc.
Dinotherium sp. mihi.
Stegodon sp.

PERISSODACTYLA.

Rhinoceros, 2 sp. mihi.
Listriodon sp.

ARTIODACTYLA.

Merycopotamus sp. mihi.
Chalicotherium. sp.
Ruminant sp. (astragalus.)

The last beds that I have introduced into the pliocene group are the mammaliferous gravels of Perim Island, in the Gulf of Cambay; most of the species were noticed by Falconer; the list comprises—

PROBOSCIDIA.

Mastodon latidens Falc.
Mastodon perimensis Falc.
Dinotherium indicum, Falc.

PERISSODACTYLA

Acerotherium perimense, Falc.
Rhinoceros sp. non-des.

ARTIODACTYLA.

Bramatherium perimense, Falc.
Camelopardalis sp. Falc.
Capra, sp. mihi. Ind. Mus.
Antilope sp. mihi Ind. Mus.
Sus hysudricus Falc.

The Mammalian fossils which I have provisionally placed under the head of Miocene comprise three groups; the first of these is from Kushalghar, forty miles to the south of Attock. In the early part of the present year I made a journey to Attock for the purpose of re-discovering the beds from which these fossils had been obtained; unfortunately I had not been correctly informed as to the precise locality at which the fossils had been found, and I was consequently unsuccessful in the main object of my journey. The exact horizon of these beds must therefore be still an unsettled question: from the marked difference between their small fauna and that of the typical Siwalik area, I am inclined to think that they may belong to a somewhat earlier period, such as the Náhan of Mr. Medlicott; red strata corresponding to the latter occur in the neighbourhood from which the fossils were obtained. The original specimens from this locality are now in the Indian Museum; those to which Falconer's name is added in the following list were shortly noticed by him in a manuscript note ("Pal. Mem., Vol. I, p. 415); the following list contains all the species known to me from this locality;—

PROBOSCIDIA.

*Mastodon sp. Ind. Mus.*
*Dinotherium pentapotamicum, Falc.*

PERISSODACTYLA.

Listriodon pentapotamiæ, Falc. (gen. mihi.)
Rhinoceros sp. n. Ind. Mus.
Antoletherium, Falc.

ARTIODACTYLA.

Merycopotamus sp. mihi.*
Dorcatherium sp. mihi.
Sus pusillus, Falc.

CARNIVORA.

Amphicyon sp. n. Falc.

With regard to other formations below the typical Siwaliks, the fossils are so few and so fragmentary, that very few of them can be specifically determined. Mr. Wynne has collected a fragmentary tooth of a species of *Mastodon* from the Náhan beds of the Bakrálá range near Jhilum. From the Sabáthú nummulitic beds of Fatehjang and its neighbourhood Mr. Wynne has obtained a considerable series of bones, but mostly in a very unsatisfactory condition.

From the beds immediately overlying the Mammaliferous clays of Fatehjang, I have recognised the perfect astragalus of an Artiodactyle animal; the form of this bone shows that the navicular and cuboid were united; the animal was therefore probably a Ruminant. From the Sabáthú nummulitics we have a femur of a Perissodactyle animal allied to *Rhinoceros.* These are the oldest Mammalian remains yet discovered in India.

Having now shortly noticed the faunæ of the various Mammaliferous beds of India, it remains firstly to consider their relationship one to another, and subsequently the relationship of the whole group to the living and fossil Mammalian faunæ of other regions of the globe.

* See Appendix.

On looking through the foregoing lists, it will be observed that there is but one species of Mammal common to the faunæ of the Nerbudda beds and the lower Sub-Himalayan Siwaliks, *viz.*, *Stegodon insignis;* the remains of this species are far less common in proportion to those of other animals in the Nerbudda beds than in the Siwaliks: this fact indicates that the species was rapidly dying out in the latter period, beyond which the genus is unknown. *Bubalus palæindicus* has been quite lately discovered (in company with *Camelus sivalensis*) in the topmost beds of the Siwaliks, which have not hitherto yielded other Mammalian remains: as this species is not found in the lower Siwaliks, I have placed these uppermost beds in near relation to the Nerbudda beds. Since, as noticed above, the genera *Hippopotamus* and *Stegodon* are the only forms at present not generically represented among the living Indian fauna, there can be no doubt as to the very modern age of these deposits.

The only two species of Mammalia at present satisfactorily determined to be common to the Sub-Himalayan, Irawadi, and Perim Island beds are *Acerotherium perimense* (this species was added last year to the Siwalik Fauna by Mr. W. Theobald's discovery of two well-preserved upper molars in these strata) and *Mastodon latidens.*

Both the species of *Mastodon,* which occur in the Siwaliks, are also found in the Irawadi beds; but the *Rhinoceros* of the latter deposits is very markedly distinct from any of the Siwalik species. (The molars of the Irawadi *Rhinoceros* in the Indian Museum I shall describe on a future occasion.) The species of *Hexaprotodon* are also different in the two deposits: the same species of *Merycopotamus,* however, occurs in both. *Stegodon cliftii* appears to be peculiar to the Irawadi beds; it is the species most nearly allied to the *Mastodons,* and is therefore probably the oldest of the genus; teeth of *Mastodon* are very common in these beds, while true elephants appear to be absent; but I cannot lay great stress upon this point at present; if the absence of *Euelephas* be confirmed by a more thorough examination of these strata, I should be well-nigh sure that these beds are older than the Siwaliks. A new genus of Ruminant, for which I propose the name of *Vishnutherium,* closely related to, but smaller than, *Sivatherium* and *Bramatherium,* has been determined by me from a portion of a lower jaw with teeth obtained from these beds by Mr. W. T. Blanford. Remains of specialised Ruminants like *Cervus, Bos,* and *Antilope,* as also of *Equus,* are far more rare in the Irawadi beds than in the Siwaliks—facts probably pointing to the somewhat older age of the former.

From the Mammaliferous beds of Perim Island, *Acerotherium perimense* and *Mastodon latidens* are the only two Mammals which I have been able satisfactorily to identify with the Siwalik fauna; the one molar of *Sus* from Perim in the Indian Museum seems, however, to be the same as the Siwalik *Sus hysudricus.* All the other species at present determined are peculiar to this district: out of seven genera, four are quite extinct, and two of these, *viz.*, *Dinotherium* and *Bramatherium,* are not found in the typical Sub-Himalayan Siwaliks. The presence of the former of these genera indicates a relationship between this fauna and that of Sind, and the Attock beds.

The extinct Mammalian fauna of the Siwaliks of Sind, as far as it is at present known, seems to indicate a group distinguished from that of the typical Sub-Himalayan deposits. Among the small but interesting collection of fossils brought from this district by Mr. Fedden, I notice the absence of *Equus* and Bovoid Ruminants, and the presence of *Dinotherium, Dorcatherium,* and *Merycopotamus* (all extinct). *Listriodon* has been found in these beds, and single teeth have been obtained from Attock and the Potwar (Theobald), but not from the true Siwaliks of Falconer: it would therefore seem probable that this genus in tertiary times was confined to the western side of Upper India, not ranging into the Ravi and Satlej districts. Two species of *Rhinoceros* have been brought by Mr. Fedden from these beds: one of them is different from either of the Siwalik species, and allied to *R. deccanensis* of Mr. Foote, while the other approaches to *R. palæindicus*. The species of *Listriodon* appears to me to be the same as *Listriodon pentapotamiæ* from Attock. I think it probable from this fauna, either that it was separated from the typical Siwalik fauna by physical barriers, or that it might have been slightly older. Mr. Fedden tells me that the Mammals from these deposits are found nearly at the base of the fresh-water series; in the Potwar district, on the other hand, they occur nearly at the top: this suggests that the Sind fauna is somewhat the older.*

The fauna of the Kushalghar beds near Attock comprises a small group of Mammalia, in which the species and in many cases the genera are quite distinct from those of the typical Siwalik area; all the specimens from this locality are molar teeth in an excellent state of preservation, so that there can be no doubt as to the correctness of their specific identification; the fossils are embedded in a red clay matrix, which lends confirmation to my suggestion that they may belong to the Náhun zone of Mr. Medlicott. Among a total number of nine genera from these beds no less than five are extinct; one of these genera, *Dinotherium* (as noted above) is unknown in the typical Siwaliks; while another, *Antoletherium*, is peculiar to these beds: a third, *Amphicyon*, is only known in the typical Siwaliks, from a single carnassial tooth of the lower jaw brought by Mr. Medlicott from the red-clay and sandstone beds of Núrpúr (these beds are placed quite at the base of the Mammaliferous Siwaliks); the Attock specimen, which is an upper true molar, must have belonged to a much smaller animal than the Siwalik specimen; and the two species were doubtless distinct. The *Merycopotamus* of the Kushalghar beds seems to be the same as the Siwalik and Burmese species †; a lower molar of *Rhinoceros*, from the same locality, is quite distinct from those of either of the Siwalik species of the genus. A species of *Dorcatherium* from these beds may or may not be distinct from Falconer's Siwalik species, the original and description of which seems to have been lost, the name only appearing in a manuscript note. A very small and distinct species of *Sus* (the animal could scarcely have been larger than Hodgson's *Porcula salvania*) is also peculiar to these beds. *Listriodon* has only just been found in the Siwalik strata by Mr. Theobald; it existed in the lower Miocene of Europe: I think the Siwalik species is the same as Falconer's *Listriodon pentapotamiæ*.

Apart, therefore, from the position of these Kushalghar beds in the geological series, their Mammalian fauna is found to be very markedly distinct from that of the Siwaliks, From the presence of such, simple forms as *Antoletherium Dinotherium* and *Listriodon* together with *Amphicyon* and *Dorcatherium*—all European Miocene forms—and from the absence, hitherto, of all such specialized types as *Bos*, *Elephas*, *Equus*, &c., we are led to place this fauna in closer connection with the ancestors of the true Siwalik fauna. Whether the age of the fossils is really pre-Siwalik, or whether the animals from which they were derived lived in part contemporaneously with the Siwalik fauna, but shut off from it by physical barriers, must remain an open question until the exact position of the beds is determined; at all events there seems to be a distinctness in the fauna of all the Mammaliferous beds of the western side of India from those of the typical Siwaliks of Falconer. *Dinotherium* and *Listriodon* are only found at Attock, in Sind, and at Perim. The above comparisons tend to show that the Burmese Fauna, though different, still

* In my note on *Stegodon ganesa* (Rec. Geol. Surv. India, Vol. IX, pt. 2, p. 45) I made the error of calling these beds "supra-nummulitic" instead of Siwalik. Mr. Blanford's paper on Sind was not published when I wrote the paper.

† See Appendix.

has considerable relations to the Siwalik, indicating some land connection between the two areas, perhaps something like that which exists at the present day; on the other hand, the Faunæ of Perim Island and the Kushalghar beds are markedly distinct. Nothing definite can at present be predicted regarding the other beds.

Having now shortly glanced at the relations of the fossil fauna among themselves, we may consider their relations firstly to the present fauna of the globe, and secondly to the fossil fauna of other regions. The lists given above (excluding the Post-Pliocene period) contain upwards of forty-six well established genera of Mammalia; of these, the following twenty-five, or rather more than one-half of the total number, are now extinct, *viz.*:—

PROBOSCIDIA, *Mastodon, Stegodon, Dinotherium.*
PERISSODACTYLA, *Antoletherium, Acerotherium, Hippotherium, Listriodon.*
ARTIODACTYLA, *Hexaprotodon, Tetraconodon, Merycopotamus, Hippohyus, Bramatherium, Vishnutherium, Sivatherium, Hemibos, Amphibos, Peribos, Dorcatherium, Chalicotherium.*

RODENTIA, *Typhlodon.*
CARNIVORA, *Drepanodon, Amphicyon, Hyænarctos, Ursitaxus, Enhydriodon.*

Of the remaining genera there are now found living in India or the adjacent countries the following seventeen, *viz.*:—

PROBOSCIDIA, *Euclephas.*
PERISSODACTYLA, *Rhinoceros, Equus.*
ARTIODACTYLA, *Cervus, Antilope, Capra, Bison (Poephagus), Bos (Bibos), Sus.*
RODENTIA, *Hystrix.*
CARNIVORA, *Felis, Hyæna, Lutra, Canis, Ursus.*
QUADRUMANA, *Semnopithecus, Macacus.*

The above list shows that rather more than one-third of the genera of the middle tertiary Mammalia of India are still living in Asia; if now we turn to the living Mammalian fauna of Africa, we find the following twelve genera common to it and to the Indian Tertiary Mammalian Fauna, *viz.*:—

PROBOSCIDIA, *Loxodon.*
PERISSODACTYLA, *Rhinoceros, Equus.*
ARTIODACTYLA, *Hippopotamus (representing Hexaprotodon), Bubalus, Camelopardalis, Capra, Antilope.*
CARNIVORA, *Hyæna, Lutra, Felis, Canis.*

As being closely connected with our present subject, we may notice here the great number of living Mammalian genera common to the continents of India and Africa (south of the Sahara). The following list of forms (exclusive of Cheiroptera) common to the two continents was kindly given to me by Mr. W. T. Blanford; it comprises twenty-three genera, *viz.*:—

PROBOSCIDIA, *Elephas (Loxodon* in Africa *and Euelephas* in India.
PERISSODACTYLA, *Antilope (subgenera), Gazella, Capra, Bubalus.*
SIRENIA, *Halicore.*
RODENTIA, *Sciurus, Hystrix, Mus, Gerbillus, Lepus.*
INSECTIVORA, *Erinaceus, Sorex (Crocidura).*
CARNIVORA, *Felis (sp. leo.* and *leopardus), Canis (sp. aureus), Mustela* (Himalayas), *Hyæna, Viverra Paradoxurus, Lutra, Aonyx, Herpestes, Mellivora.*

Again, we find the twenty-six following genera common to the Indian Tertiaries and to the Tertiaries of Europe, *viz.* :—

PROBOSCIDIA, *Mastodon, Loxodon, Euelephas, Dinotherium.*
PERISSODACTYLA, *Rhinoceros, Acerotherium, Equus, Hippotherium, Listriodon.*
ARTIODACTYLA, *Hippopotamus, Sus, Chalicotherium, Dorcatherium, Cervus, Bos, Bison, Capra, Camelopardalis.**
CARNIVORA, *Amphicyon, Ursus, Felis, Drepanodon, Hyæna, Lutra, Hyænarctos, Canis.*

From the above list we find that more than half the number of genera of Mammalia which occur in the Indian Tertiaries are also found in the Tertiary fauna of Europe. In contrast to this if we turn to the living fauna of Europe, we find the following eight genera common to it and the Indian Tertiary fauna, *viz.* :—

ARTIODACTYLA, *Sus, Bos, Bison, Capra, Cervus.*
CARNIVORA, *Ursus, Felis, Lutra.*

Finally we find the following fourteen genera peculiar to the Indian Tertiaries :—

PROBOSCIDIA, *Stegodon.*
PERISSODACTYLA, *Antoletherium.*
ARTIODACTYLA, *Hexaprotodon, Tetraconodon, Merycopotamus, Hippohyus, Peribos, Hemibos, Amphibos, Sivatherium, Bramatherium, Vishnutherium.*
CARNIVORA, *Ursitaxus, Enhydriodon.*

From the foregoing we arrive at the following results: firstly, that all the species of Mammalia found in the Indian Tertiaries below the Nerbudda beds are extinct; and that the following are the relations of the genera:—

| | |
|---|---|
| Extinct ... ... ... ... ... | 25 |
| Peculiar to Indian Tertiaries ... ... ... | 14 |
| Common to Indian and European Tertiaries ... ... | 26 |
| Common to fossil and living Indian fauna ... ... | 17 |
| Common to Indian Tertiaries and modern Africa ... | 12 |
| Common to Indian Tertiaries and modern Europe ... | 8 |

The greatest number of genera common to any two periods occur in the Tertiaries of Europe and India; next to them the greatest common number is found in the living and fossil Indian fauna; thirdly, a small number of genera is common to the extinct fauna of India, and the living fauna of Africa; a few genera are common to the extinct Indian fauna and the modern European fauna; while a larger number of genera are common to the living faunæ of India and Africa.

The above results appear clearly to point to some former connection by land between the continents of India, Africa and Europe. The former land connection between India and Africa has been strongly insisted upon by several modern naturalists; this ancient land connection has been named "Indo-Oceania" by Mr. H. F. Blanford in a recent paper, (Quart. Jour. Geol. Soc. Lond., November 1875) by which name it will be cited here. The writers who have argued for the existence of this ancient continent have been led to form their opinions by the study of their own particular branches of science; another line of evidence derived from the fossil Mammalia cannot but add strength to the hypothesis.

* Up. Miocene of Attica: and perhaps in France; see Gervais, Palæontologie et Zoologie Français, p. 142.

Assuming the truth of this hypothesis, we must, in considering the relations of the extinct to the modern fauna of India, divest ourselves of the idea of peninsular India being connected by means of the Himalaya with Central Asia; rather we must look upon it as having been disconnected from the latter region by a deep Eo-Miocene sea, which deposited the extensive nummulitic formations of the Himalaya and Persia; and as having been connected by the old "Indo-Oceania" with Africa, and so with Europe. Subsequently to the (at all events partial) upheaval of the nummulitic series and its overlying sandstones and red clays, the great fresh-water Mammaliferous series was deposited: and it becomes an interesting question to consider whether these were deposited previously or subsequently to the submergence of "Indo-Oceania."

Before there can be any chance of answering this question, the geological age of the Siwaliks must be certainly fixed; whether in fact they should be placed in the Miocene or Pliocene period. The number of extinct genera of Mammalia in these beds is so large, that on first thoughts one would be at once inclined to say that they cannot be of later age than Miocene: this view was taken by Dr. Falconer, and has been subsequently acquiesced in by most other writers. In considering this question we must, however, bear in mind, that it does not at all follow that the same rule holds good in India as in Europe; changes of climatal and physical conditions, and consequently of the forms of life, may have been infinitely more rapid in the one region than in the other.

Besides the Mammalian remains, a considerable number of species of Mollusca have been collected from the Siwaliks; these were sent by Dr. Falconer to the late Prof. E. Forbes for determination; a considerable number were identified with living forms, and Mr. Theobald now tells me that he believes (owing to the more complete collections of living species now extant) nearly all are identical with living species. At the end of his note on the subject (Pal. Mem., Vol. 1, p. 390) Prof. Forbes says that the Molluscan evidence tends to place the age of the Siwalik Fauna as not newer than older Pliocene; if, however, Mr. Theobald's suggestion turn out to be correct, the age would, from the Molluscan evidence, be later than this. In the first volume of the Palæontological Memoirs (p. 26) it is stated that in the opinion of a then eminent authority (Mr. Benson), nearly if not quite all the Siwalik shells were identical with living species. Our collection of these shells in the Indian Museum is not at present very extensive; if additional specimens be obtained, it would be very important to have the whole series carefully compared with their living congeners.

There is, however, the still more important fact, that the Gharial of the Siwaliks, and one species of Crocodile, are absolutely indistinguishable from their living Indian representatives, whilst there is, I believe, no instance of reptiles having survived from the Miocene to the present period. Both of the above facts to my mind point very strongly to the Pliocene age of the Siwaliks: *Emys tectum* is also another Siwalik Reptile which has survived down to the present time.

Another very important piece of evidence tending to the same view is afforded by a statement of Mr. W. T. Blanford's (Rec. Geol. Surv. India, Vol. IX, pt. 1, p. 18) in his Geology of Sind; it is there shown that the Manchhar beds, which he correlates with the Siwaliks (and from the few fossils brought from them, I should say that they cannot possibly be newer) rest unconformably on beds "which are at the oldest Upper Miocene." If this identification is certain, it at once disposes of the Miocene theory of the age of the Siwaliks.

The assemblage of Mammalian genera in the Siwaliks, and other Indian Tertiaries, is so incongruous, according to our ideas derived from the European fauna (as was long since pointed out by Dr. Falconer), that it seems to be impossible from this alone to decide their age. Forms such as *Chalicotherium*, *Acerotherium* and *Dorcatherium* are very characteristic of the Miocene of Continental Europe; but then we find mixed with them such markedly modern forms as *Equus, Hippopotamus* and *Bos,* just as characteristic of the Pliocene in Europe; and it is from the presence of these and kindred genera that I am inclined to give my adherence to the view of the modern age of these strata; rather than, led away by the presence of older forms, which might well have lived down to a later period in this country than in Europe, to place the Siwaliks in the Miocene period. Mr. W. T. Blanford, in the paper above quoted (page 18, note), attaches much weight to the presence of specialised Ruminants in the Siwaliks, as indicating their Pliocene age: and the absence of genera like *Palæotherium* and *Anoplotherium,* as far as negative evidence goes, also tends to prove the modern age of the Siwaliks; with regard to Mr. Blanford's remark, however, it is mentioned in the report on the Miocene Mammals of Attica (Compt. Rend Vol. LI, p. 1296) that "L'abondance des Ruminants est remarquable à Pikermi:" and yet the strata are placed as Miocene.

Assuming, however, the Pliocene age of the Siwaliks, and the former connection of India with Africa, we still have to account for the number of generic forms common to Tertiary India and Tertiary Europe: this, however, presents no difficulty, because it is, I believe, a well-established fact that Southern Europe and Northern Africa were connected by land in middle tertiary times; so that a land communication (not necessarily continuous at any one period) must have once existed between India and Europe, across the Indian Ocean, allowing of the free migration of the Mammalia of the three great continents.

According to this view of the case, we may readily conceive how a European Miocene genus like *Helladotherium* or *Camelopardalis* (both found fossil on the extreme southern *borders of Europe) may have lived in these regions, in Northern Africa and in the intermediate submerged land, and so may have given origin to the Camelopardalis of the latter continent, and also to the Sivatherium, Bramatherium* and *Giraffe* of the Indian Tertiaries, which lived in the succeeding Pliocene period. The same may be said of *Elephas* and *Hippopotamus,* some forms of both of these genera being found either living or fossil in all the three continents; both genera might have taken their origin in the Miocene "Indo-Oceania," or adjacent lands, and thence spread out on all sides; to live in one continent up to Pliocene and Post-Pliocene times only, and in the other two to exist up to the present day.

The presence of such genera as *Equus* and *Bos* in the Pliocene of Europe, and in the Siwaliks of India—genera which are still living in both continents—appears to lead to the conclusion that the connecting land between India and Europe must have existed down to a comparatively modern period: and that perhaps some portion of the Siwalik strata were deposited during the period of this union.

The very large number of Mammalian genera common to the Indian and European Tertiaries, and the comparatively small number common to the former and to the living Fauna of Europe, seem to point to an earlier separation between India and Europe than between India and Africa; the Faunæ of the two latter countries still have so many forms in common, that it appears only a relatively short period of time can have elapsed since their separation; a period not long enough to have modified the genera, and in several cases not even the species. Between India and Europe, on the other hand, the relationship between the living Mammalian genera is much less close; and we have to go back to the Miocene period of the latter country, and to the Pliocene period of the former, to find conclusive evidence of a former land communication between the two. Still, as before said, certain living genera are now common to both countries, and we must bear in mind that, assuming the former union of the three great continents of the old world, India and Europe would be situated at the two ends of the chain, and that, therefore, their faunæ would naturally differ most: moreover, the continents of modern India and Europe differ now (irrespective of what may have occurred in Tertiary times) very greatly in climate, and to this cause alone we may attribute in great part their present divergence in faunæ.

If a more complete series of Mammalian remains should hereafter be discovered in the Tertiary strata of Africa, we may confidently expect to find among them more conclusive evidences of the former mingling of the faunæ of the three great continents of the old world. Among the few Mammalian remains which have been obtained from the upper Tertiaries of Algiers, there is a species of *Bubalus* (*B. antiquus:* see Gervais' "Zoologie et Palæontologie," 1st series, pl. XIX), which approaches much nearer in the form of its cranium to *Bubalus arni* of India, than to any living African species of the genus; certain characters, however, relate it to *B. brachyceros* of the latter continent. Intermediate forms like the above afford the most conclusive evidence of the former connection of the two continents.

The presence of two or three genera of Mammalia in the Siwaliks seems to indicate that at some period of time the fauna of the Indian region must have had communication with the progenitors of the American Fauna; for instance, the genera *Mastodon* and *Equus* are common to the Tertiaries of Europe, Asia and America: *Sivatherium* is not only related by the form of its molar teeth to *Camelopardalis* and *Megaceros*, but in the structure of its horn-cores it approaches the American *Antilocapra*, and no other living Mammal. *Camelus*, again, which is found fossil in the Indian Tertiaries, and in no other formations in the world, must have had some relationship with the ancestors of the Lamas and Vicuunas of the Cordilleras: a fact which I have just discovered confirms this point: the Siwalik camel presents a peculiarity in the lower molars which is not found in the living species, but exists only in the American *Auchenia*.* If camels exist wild in Turkestan, the presence of the genus among the Siwalik fauna is one of the few instances in which that fauna is related to the fauna of Central Asia.

No remains of *Edentata* (now sparingly represented in India) have hitherto been described from the Siwaliks. *Insectivora* are likewise unknown; and no specimens of *Rodentia* have been obtained since Falconer's original specimens. As is so generally the case among older faunæ, many of the Tertiary animals of India vastly exceeded in size their modern representatives; as instances we may note, *Stegodon ganesa*, *Sivatherium*, *Bramatherium*, *Rhinoceros platyrhinus*, *Hyænarctos sivalensis*, and above all *Colossochelys gigantea*.

With regard to the presence of man among the fossil fauna of India, it will be noticed that the discovery of a stone weapon in the gravels of the Nerbudda by Mr. Hacket, and of another by Mr. Wynne, in the Godávari Valley, have confirmed the suggestion of Dr. Falconer (Pal. Mem., Vol. II, page 577) that man would one day be found in these deposits. No traces, however, of man have yet been discovered in the Siwaliks, though Falconer thought they might occur even here; and on the theory of these beds being Pliocene, occurrence of human remains is still more probable; even yet I think all hope of finding them is not exhausted, especially when we remember how very rare are the remains of any Mammals of the anthropoid type; the one tusk of an Ape allied to the Orang, found by Falconer (Pal. Mem., Vol. II, page 578) is still the only specimen of the species hitherto discovered among the many thousands of specimens brought from these deposits. It must also be borne in mind that the whole of the Siwalik fossils are derived from strata and not from caverns, and that, therefore, the chance of finding human remains among them is so much the less.

* This peculiarity will subsequently be fully

Lastly, I would conclude with a few words as to the past and present physical features of the Siwalik region, and as to the causes which have led to the complete extinction of the old Fauna. My remarks will chiefly have reference to that portion of the Siwalik area lying between the rivers Satlej and Indus, as being that with which alone I am personally familiar.

The present Siwalik hills consist of a series of comparatively low ranges, with a general north-west strike, forming the outermost bands of the Himalaya (see Mr. Medlicott: Mem. Geol. Sur., India, Vol. III, and Mr. Drew: "Jamú and Kashmír Territories"), here and there pierced through and broken up by masses of the underlying formations: even their very topmost beds are contorted and crushed in every conceivable manner, indicating the lateness of the period down to which the upheaval of the Himalaya has extended.

These hills are either completely bare, or are covered with forests of *Pinus longifolia* and *Picea Webbiana*, or with low scrub jungle: the "dúns" between the ridges are generally cultivated and fairly fertile. The rivers are generally confined to narrow channels in deep-cut gorges, and never that I am aware of spread out into lakes: isolated lakes of any size are also very rare. On the uncultivated lands natural herbage (fit for food) is extremely scarce; and in its present condition the country seems to me entirely unfitted for the support of a fauna such as that of which we find the remains embedded in its strata.

Mr. Medlicott, however, has reminded me that the old Moghul Emperors used to hunt the elephant in the Jamú hills; and it therefore seems likely that cultivation must have had a share in rendering this part of the country unfit for the habitation of large game. Further to the east the Siwalik area still abounds in jungle, in which the elephant is found abundantly.

Several of the Mammalia found in the Siwaliks of Jamú belong, however, to genera which live in the open sparingly-watered plains of Africa; such are *Equus* and *Camelopardalis*. The *Hippopotamus*, however, on the other hand, is only found at the present day inhabiting large and deep rivers, with pools and lagoons, and on the banks of which grow abundance of rank and succulent vegetation; and, to my mind, could not have possibly lived in any of the rapidly-flowing rivers of Jamú.

If, on the other hand, we glance back at what might have been, and very probably was the character of the country during the deposition of the Siwalik strata, we may readily imagine a physical condition much more suited to animals like the hippopotamus.

Since, in the Jamú district, at all events, the Siwalik strata are carried up and contorted by the conformable underlying rocks, it is evident that these older rocks have only been raised at a comparatively recent period to the elevation at which we now find them, and that consequently in Siwalik times the whole of the outer belt of the Himalaya must have been much lower than at present. This lower elevation would imply a smaller degree of fall in the rivers (which Mr. Medlicott supposes to have flowed in the same courses in Siwalik times as at present) and these consequently, instead of denuding, would have been depositing in the Siwalik districts, and might have wandered in sinuous courses over extensive marshy plains, spreading out here and there into lakes: under such conditions we may readily imagine the country to have abounded with dense jungles of succulent plants suited for the support of large herbivores like the hippopotamus, rhinoceros, elephant, &c.; the condition of the country was probably more like that of Assam at the present day, where the rhinoceros, elephant and buffaloe still exist. Evidence of the former existence of extensive forests in these regions is afforded by the vast number of tree-stems found in the Náhan sandstone of Jogi-Tillá near Jhilam, and more sparingly in other places.

During the whole of this "depositing-period" the innermost band of the upper Tertiaries (Náhans) was probably being gradually upheaved, while its detritus was again deposited in the outer band: in course of time the elevation of the inner regions would become so great as to cause the rivers to begin to cut through the outer Siwaliks, and so gradually to drain the country; the Siwalik strata becoming contorted and crushed as they were slowly upheaved. This gradual draining of the country and consequent disappearance of a great part of the vegetation would, I imagine, have been of itself a power quite sufficient to have caused the total extinction of migration of the old Siwalik Fauna from these regions without invoking the aid of man or any other living agent.

Why some genera like *Camelopardalis* and *Hippopotamus*, apparently as well fitted as *Elephas* or *Rhinoceros* to have survived in other parts of India, should have entirely disappeared from the country, while others like *Sivatherium* should have become totally extinct, it is useless to conjecture in our present state of knowledge.

It may be observed that the whole of the Siwalik Mammalia belonged to genera fitted for life in the plains or in low jungle-clad hills, not barren and lofty mountains: we mark the presence of genera like *Elephas*, *Camelus*, *Camelopardalis*, *Equus*, *Hippopotamus*, and *Rhinoceros*, and note the rareness of *Capra*, *Ibex*, *Ovis*, *Nemorhædus*, and similar mountain genera. Certain beds in Tibet (General Strachey, sup. cit.), however, presumably of Siwalik age, have yielded either an *Ovis* or *Capra*: the further exploration of these strata would probably show a more intimate connection between their fauna and that of Central Asia than is found to exist between the latter and the typical Siwalik Fauna.

## APPENDIX A.

*Descriptions of some new or little known Mammalia from the Indian Tertiaries.*

TETRACONODON MAGNUM, Falconer.

This genus was originally founded by Falconer upon two upper molar teeth from Dadúpúr; ('Palæontological memoirs', Vol. I page 149) these teeth have apparently been lost; but a drawing is given in the memoir quoted: no other specimens of the genus have ever been recorded. The molar teeth indicate an animal of the hippopotamus family.

In the present season Mr. Theobald has sent down from the Siwaliks of Asnot in the Potwar district a portion of a right mandible of a Hippopotamoid, containing the first and second molar teeth, and the ultimate premolar, together with the penultimate premolars of both sides of the jaw. The molar teeth of this specimen seem to correspond in general character with the molars of Falconer's *Tetraconodon* so closely, that I have referred the present specimen to the same genus and species.

The second molar tooth has not yet come into full wear, and is in excellent state for description. The crown of this tooth is oblong in shape; it is produced at its angles into four conical or mastoid processes, forming a pair at each end. A cruciform valley occupies the surface of the crown between the four cones; the transverse portion of this valley is the widest and deepest; the extremities of this transverse valley extend downwards to the sides of the crown. At the central hollow between the four cones there is a bilobed flat tubercle; another talon tubercle occupies the hindmost portion of the antero-posterior valley; there is a very small tubercle at the outer extremity of the transverse valley. There is no cingulum.

On the worn surface of the first molar the plane of wear slopes very slightly outwards.

The resemblance between this penultimate lower molar and the penultimate upper molar of Falconer's specimen (as may be seen by comparing the two descriptions) is complete; and on the evidence of this tooth alone I have united the two specimens under one species.

I now come to the premolar teeth of my specimen, hitherto unknown, and which are of a most abnormal and interesting character. These teeth vastly exceed in size the true molars, a character which is, I believe, unknown among other mammals; they are placed in direct contact with the molar series, and have a general resemblance in form to those of *Hippopotamus* and *Merycopotamus*; each is inserted into the jaw by two fangs; the penultimate premolar does not present any facet of pressure on its anterior surface, and was therefore probably separated by a diastema from the preceding tooth.

The ultimate premolar has a nearly square base, from which rises an oblique compressed cone, the summit being directed backwards and placed a little in advance of the hindmost border of the crown; the anterior face of the cone projects into a sharp sinuous ridge running from summit nearly to base, expanding below into a cingulum, which occupies the greater part of the anterior base; the cingulum slopes from the ridge to the antero-external angle. A small tubercle occurs between the summit of the cone and the posterior border; this tubercle forms the summit of another cingulum occupying the posterior surface; the posterior cingulum slopes towards the base of the crown on each side from this central point; the outer extremity of the cingulum forming a very marked ledge at the postero-external angle of the crown; a rounded notch occupies each side of the crown between the roots of the fang. The inner surface of the tooth is nearly vertical, the outer sloping.

The enamel is arranged in irregular branching ridges radiating from the summit to the periphery of the base; these ridges are again marked by fine parallel transverse striæ.

The summit of the crown is worn obliquely, the face directed upwards and backwards; the worn surface present two facets, and is of an irregular oval shape, the longer diameter placed antero-posteriorly.

The penultimate premolar differs from the other in being rather smaller in the base of the crown presenting a somewhat triangular cross-section, and in the summit of the cone being more directly over the centre of the crown. A more prominent ridge from this summit runs along the centre of both anterior and posterior surfaces; the posterior cingulum is also rather more prominent.

The dimensions of the specimen are as follows, in inches and tenths:—

| | |
|---|---|
| Length of two molars ... ... ... ... ... ... ... ... | 2·50 |
| Ditto 2nd molar ... ... ... ... ... ... ... ... ... | 1·45 |
| Width of ditto ditto ... ... ... ... ... ... ... ... ... | 1·30 |
| Height of ditto ditto ... ... ... ... ... ... ... ... ... | ·80 |
| Length of ultimate premolar ... ... ... ... ... ... ... ... | 2·15 |
| Width of ditto ... ... ... ... ... ... ... ... ... ... | 2·10 |
| Height of ditto .. ... ... ... ... ... ... ... ... ... | 1·80 |
| Length of penultimate premolar... ... ... ... ... ... ... ... | 2·05 |
| Width of ditto ... ... ... ... ... ... ... ... ... ... | 1·80 |
| Height of ditto ... ... ... ... ... ... ... ... ... ... | 1·65 |
| Depth of jaw at ultimate premolar ... ... ... ... ... ... ... | 3·10 |
| Length of the penultimate molar of Falconer's specimen ... ... .. ... ... | 1·40 |

The general form of the premolars resembles those of *Hippopotamus*: the cingulum, however, is confined to the fore and aft surfaces only. In the position of the cingulum, and in the straightness of the inner wall of the premolars, the specimen approaches the premolars of *Merycopotamus*.

As stated by Falconer, the molars can only be compared with those of *Hippopotamus* and its allies; the position of the four cones at the corners, and the absence of the trefoil-shaped surface of wear, sufficiently distinguishes the molars from those of *Hippopotamus*. From *Sus* they are distinguished by the slight degree of obliquity of the worn surface, and from the crown surface not being a collection of semi-distinct tubercles, but divided into four distinct simple cones. The cruciform valley is a character common to this genus and *Sus*.

The distinction between the molars of this genus and *Anthracotherium* are well pointed out by Falconer in his memoir.

The peculiar form and size of the premolars, now first known, (sufficiently differentiate this) remarkable genus from all its congeners. The gigantic size of the premolars appears to be a further extension of the ultra development of the anterior teeth, which is found in *Hippopotamus* and *Sus*: in the living genera this ultra development is confined to the canines and incisors only, while in the fossil genus it extended back to the premolars. It is to be hoped that further researches may bring to light the cranium and anterior teeth of this most remarkable mammalian form.

The genus was called by Falconer by the two names of *Tetraconodon* and *Chærotherium* The latter name is now applied to a small suine animal from Sausans, (Lar); (see Ann. Mag. Nat. Hist. Ser. IV, Vol. XII, p. 177). For this reason I have here called the genus by its forme name only.

### VISHNUTHERIUM IRAVADICUM (nov. gen. mihi.)

Genus founded on a portion of a left mandible discovered by Mr. W. T. Blanford in Burma; the specimen contains the first and second true molar teeth. The general form of the molars is like those of *Camelopardalis, Sivatherium,* and *Bramatherium,* and the enamel has the same rugose character; the teeth are, however, distinguished from those of either of the above genera by the following characters:—

Along the whole of the external surface of each molar there is a well-marked sinuated cingulum; this extends half way across the posterior and anterior surfaces, where it is very conspicuous: it is produced into a number of cusps on the anterior surface; there is a prominent tubercle at the entrance to the main valley between the barrels: the other characters differ but slightly from those of the teeth of the above genera.

| | |
|---|---|
| Length of two molars ... ... ... ... ... ... ... ... ... | 3·8 |
| Ditto of last ditto .. ... ... ... ... ... ... . | 1·45 |
| Breadth of ditto... ... ... ... ... ... ... ... ... ... | 1·0 |

This genus is distinguished from *Sivatherium* and *Bramatherium* by its small size, and by the presence of the cingulum and tubercle; from *Camelopardalis* by the presence of a cingulum, and by the tubercle being pointed and present in both molars, instead of being blunt and only present in the first molar: other minor differences will be noted when the specimen is figured and described fully.

## APPENDIX B.

The following is a summary of the new forms added to the Siwalik fauna by the collections brought down during the present year by Mr. Theobald, together with notices of some of the more remarkable and rare specimens of previously known species.

Perhaps the most interesting of these additions is a specimen of the tympanic bone of a species of Cetacean: the specimen presents some points of affinity to the corresponding bone of *Platanista,* and is of about the same size; it, however, presents such differences as will probably necessitate its being placed in a distinct genus. This is the first instance of a Cetacean bone having been obtained from the Siwaliks, though Falconer conjectured that they would eventually be discovered

Two genera, though previously known in other tertiary beds of India, have now been for the first time added to the true Siwalik fauna: these are *Listriodon* and *Acerotherium.*

Of the genus *Bos* and allied forms, four new species have been added to the Siwalik fauna: descriptions of these will shortly be published in the "Palæontologia Indica."

*Rhinoceros*: a new species of this genus, founded on upper molar teeth, has also been obtained.

*Tetraconodon magnum*, hitherto known by the drawing only of the Dadúpúr specimen, is represented by the jaw noticed above.

*Lutra*: a portion of a lower jaw, which seems to be larger than *Lutra palæindica*, and may perhaps be distinct.

*Bramatherium*.—Of this genus we have obtained a very perfect cranium, not yet cleaned from its matrix; the teeth are complete, and the cranium seems only lacking the horn-cores to be also complete: this is, I believe, the first perfect cranium discovered.

*Dorcatherium* sp.—A number of molar teeth and jaws; the upper molars indicate the existence of two species.

*Camelopardalis sivalensis*.—Part of a lower jaw, and two upper molars.

*Merycopotamus sivalensis*.- Several portions of lower jaws, and an astragalus.

*Ursitaxus sivalensis*.—The first true molar, and the last premolar from the maxilla of each side; these teeth are valuable additions to our collection, as the genus has been hitherto known only by Falconer's two specimens: the one a cranium, and the other a fragment of a lower jaw.

*Hyæna sivalensis*.—Several fragments of lower jaws.

*Felis* sp.—One lower carnassial tooth.

*Ursus* n. sp. cranium.

In addition to the Mammalian specimens, I have also to notice the discovery of a very perfect cervical vertebra of a bird belonging to the order *Grallatores*. Falconer also had one or more specimens of bird-bones, which he referred to the same order; and it is not improbable that our new specimen may be closely allied to Falconer's. Falconer considered that his specimens belonged to a bird which must have exceeded in size the gigantic Bengal adjutant *Leptoptilus argala*.

Remains of Ophidians have not hitherto been recorded from the Tertiary Faunæ of India; it is therefore interesting to have to notice their discovery from two localities in the present year. Mr. Theobald has brought four dorsal vertebræ of a species of snake allied to, but smaller than, the Indian Python from the Siwaliks of the Potwar district; while Mr. Fedden has collected two very similar vertebræ from the Siwaliks of Sind.

I shall hope on a future occasion to give descriptions and figures of the more remarkable of these novelties.

*Note on Camelopardalis from the Siwaliks.* In looking over the collection of ruminant teeth from the Siwaliks in the Indian Museum, the great rarity of the teeth of this genus struck me as being very remarkable, especially as Falconer had determined two species, *viz.*, *Camelopardalis affinis* and *Camelopardalis sivalensis*. The former of these species was founded upon molars closely resembling those of the living African species, while the latter was founded upon a cervical vertebra. (The specimens are figured in the "Palæontological Memoirs," Vol. I, p. 198.)

It then occurred to me to consider why separate species had been made from these two series of remains, which on *primâ facie* grounds it would have seemed natural to refer to one species. I then found that in the catalogue of the Fossil Mammalia of the Asiatic Society of Bengal, there were certain teeth which had been entered by Dr. Falconer as the lower molars of the second species of *Camelopardalis* (*C. sivalensis*). These teeth are numbered in the collection $\frac{S.}{580}$ and $\frac{S.}{581}$; on examining these specimens I was greatly surprized to find that they belonged to *Bos* or some allied form, and not to *Camelopardalis* at all. (The teeth are much narrower in proportion to their length than in *Camelopardalis*; they have a long slender accessory lobe between the two cylinders, which reaches to the summit of the crown, whereas in *Camelopardalis* there is only a minute tubercle at the base of the cylinders; and finally the outer walls of the cylinders are placed nearly parallel to the long areas of the teeth, instead of very obliquely, as in *Camelopardalis*). These teeth have a somewhat rugose enamel, and I can only suppose that in a hasty examination Dr. Falconer, who says that at the time of cataloguing them he had no means of making a comparison at hand, was led away by this character into placing them under the head of *Camelopardalis.*

No teeth have therefore been found which are referable to *Camelopardalis sivalensis* ; on turning to Dr. Falconer's remarks upon the genus, it is stated that the teeth figured in the "Palæontological Memoirs" were assigned to a second species, because they were of too large a size to have belonged to an animal possessing cervical vertebræ of the size of those of the original *Camelopardalis sivalensis.*

On turning to the measurements of the vertebra of the latter species ("Palæontological Memoirs," Vol. I, p. 201), I find that the specimen was described as being one-third shorter than the corresponding vertebra of the living species; but on looking at the relative dimensions of the centre of the vertebra of the two species, I find very small differences between them; indeed, some of the diameters of the vertebra of *C. sivalensis* are actually larger than those of *C. giraffa.*

The following measurements are taken from Falconer's table :—

| | *C. sivalensis.* | *C. giraffa.* |
|---|---|---|
| Vertical diameter of anterior articulating surface of centrum ... | 1·9 | 1·55 |
| Transverse ditto ditto ... | 1·4 | 1·5 |
| Length of post-zygapophysis ... ... ... ... | 1·6 | 1·2 |
| Width of disc. ... ... ... ... ... | 1·0 | 0·8 |
| Length of pre-zygapophysis ... ... ... ... | 1·2 | 0·85 |
| Vertical diameter of posterior articulating cup of centrum ... | 2·0 | 2·3 |

From the above measurements it will be seen that the anterior articulating ball of the centrum has an area nearly equal in the two species; the diameter of the posterior cup of the vertebra of the recent species is rather the larger of the two, but this is caused by a less development of the rim in the fossil specimen. Both of the zygapophyses present a considerably larger area in the fossil than in the recent specimen ; and since their surfaces are the main aids in connecting the different vertebra, it is clear that the neck of the fossil species was at the least equally strong with that of the living species, and was therefore capable of supporting a head and teeth as large as those of the latter.

Moreover, from its shortness and consequent absence of the great leverage which occurs in the living species, the neck of the fossil species might well bear even a still larger head and teeth than those of the living species.

From the above arguments I am perfectly convinced that Falconer's second species—*Camelopardalis affinis*—founded upon the teeth alone, should be abolished, and both teeth and vertebra assigned to *Camelopardalis sivalensis.*

*Camelopardalis sivalensis,* according to this view, was an animal furnished with molar teeth (and probably with a cranium) of the same size as those of the living *Camelopardalis giraffa ;* its neck, however, was one-third shorter than that of the latter ; it probably took its origin from some short-necked form allied to *Sivatherium ;* while the long neck of the recent species is, as we should naturally expect, a specialized character of quite modern origin.

As according to the above view we have only one species of Siwalik giraffe, the rarity of the molars, though still very remarkble, is not so noticeable as if there had been two species.

*Note on Merycopotamus.*

***M. Nanus,*** Falc. This species was added to the list of Indian Fossil Mammalia by Dr. Falconer on the evidence of several molar teeth and one premolar from Kushalghar near Attock ("Palæontological Memoirs," Vol. I, p. 416).

Lately, on looking over the collection containing these specimens, I was surprised to find that the molar teeth ascribed to this species do not really belong to the genus *Merycopotamus* at all, but to the genus *Dorcatherium* : (on a hasty examination it would be possible to mistake the one or the other.)

P. S.—Since writing the above I have to add an Edentate allied to Manis, but larger, to the Sind fossil Fauna; the specimen consists of a phalange of the third digit of the manus.

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GEOLOGICAL SURVEY OFFICE,
*3rd July* 1876.

#  RECORDS

OF THE

# GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1876. [November.

## NOTES ON THE AGE OF SOME FOSSIL FLORAS IN INDIA, *by* OTTOKAR FEISTMANTEL, M.D., *Geological Survey of India.*

### VI, VII AND VIII.

### VI.—ON THE HOMOTAXIS OF THE GONDWANA SYSTEM.

In the last number of the Records (*supra* p. 79) there is a clearly written paper by my colleague Mr. W. T. Blanford, calling in question the general value of geological homotaxis as drawn from the fossil remains of terrestrial life, and based upon an analysis of the evidence for the age of our Gondwana series. The general question may safely be left to time for settlement. I have no fear that the higher forms of animal and of vegetable life can fail to take their due place in the adjustment of the records of the earth's history—a place proportionate and analogous to their importance in the world; and I therefore regret to see the question brought forward in the unbecoming and unreal aspect of a dispute between geologists and palæontologists.

Regarding the particular case, there is much to be said in correction of it as stated by Mr. Blanford. Perhaps I owe some apology for having left it possible to be so stated; but I had no idea that this discussion would be so precipitately raised, while still the materials for it are under examination. I might otherwise, in the notes already published, have anticipated some of the most serious objections brought forward in the paper under notice. I had postponed these niceties of detailed comparison till the data for it were more completely worked out, being content to state broadly the *facies* of each local flora. I must, however, as briefly as possible, remedy that omission of mine. In doing so it will be necessary to mention undescribed fossils; which, however, I describe shortly in an adjoined paper.

As to the Kach group, I had already fully noticed (*supra* p. 29) as a "palæontological contradiction" the discrepancy between the homotaxis of the group as derived from the plant remains, and as judged from the fossil *cephalopoda*, when we find strata with a middle jurassic flora intercalated with and overlying strata with four *cephalopoda* of Portlandian affinities. It would indeed be rash to question the determinations of the *cephalopoda* by Dr. Waagen; but it must not be forgotten that all the fossil *mollusca* and other fossils are not yet critically examined; and it is very possible that the full examination of the *fauna* may modify the stratigraphical relations as deduced from the *cephalopoda*, and then the "palæontological contradiction" would not be so strong. To show this, and to explain my point of view, the following observations may be given :—

1.—There are certainly some *mollusca* that are generally of older age than Portlandian, passing into the higher beds of Kach.

*a.*—I may mention only from the Umia group (which contains the Portlandian *cephalopoda*) the very frequent occurrence of—

*Goniomya-V-scripta*, which mostly occurs in middle jurassic beds in Europe.

*Astarte major*, Sow., very near with *Astarte maxima*, Om., from Middle Jura in Germany.

*A Trigonia* near *Trigonia Tau*, Sharpe, from jurassic beds on the Sunday River in Africa.

A *Goniomya* scarcely different from *Goniomya inflata*, Ag., a Middle Jurassic form—also related with *Goniomya rhombifera*, Goldf., from Liassic strata.

A *Trigonia* very near to *Trig. Herzogii*, Hausm, from Enon on the Sunday River in South Africa.

Some *Trigoniæ* allied with *Tr. ventricosa* in South Africa.

A portion of the lower jaw junction of a *Plesiosaurus*, which has mostly allied forms in the English Lias—found near Borooria in the Umia group.

*b.*—From the Charee and Katrol beds of Kach, which are especially taken as representing the Oxford group and Callovian, we have especially to mention *Monotis inæquivalvis*, Sow., in Europe generally of Liassic age—here in the Charee beds.

*Monotis Münsteri*, Goldf., generally in Europe from Middle brown Jura—here in the Katrol group which is taken as representative of the Upper Oxford group.

*Parasuchus*, a vertebra of that Crocodilian fossil which is looked upon as Triassic, and which occurs frequently with the Jabalpúr flora near Maléri, which latter is identical with our Kach flora.

Near Nurha, in the Katrol beds (therefore below the common plant horizon), the following fossil plants occur :—

*Sphenopteris arguta*, L. & H., from Inferior Oolite in England—In India occurs in the Rajmahal Series (Rajmahal Hills) and in the Jabalpúr group.

*Alethopteris Whitbyensis*, Göpp., in the form as *Pecopteris tenuis*, Bgt., from Inferior Oolite in England. Also at Kukurbit and in the Jabalpúr group.

*Otozamites* comp. *contiguus*, Fstm.—A similar form from Kukurbit.

*Araucarites Kachensis*, Fstm.—a smaller specimen of this frequent species at Kukurbit and in the Jabalpúr group.

These plant remains are mostly identical with the others from Kach and the Jabalpúr group.

2. There is a great affinity of some of the fossils in the uppermost beds of Kach with forms from the South African strata on the Sunday and Zwartkop rivers as already mentioned; and also Dr. Waagen* refers a *Trigonia* from the Umia beds to the *Trig. ventricosa*, Kr.

* Pal. Indica: Jurassic Cephalopoda of Kach, p. 237.

It is true those beds were first supposed by Mr. Krauss* to be lower cretaceous; but this has been shown to be wrong by MM. Bain,† Sharpe,‡ and Tate.‡ Mr. Bain considered those beds as Liassic; Mr. Sharpe, however, and Mr. Tate declared them from the whole of the fossils to be analogous with the great Oolite in England. Also Dr. Waagen speaks of them as Jurassic. With the fossils of those strata many of the mollusca in the uppermost strata of Kach are identical, or very nearly.

Thus it would seem that the decision from the four Portlandian *cephalopoda* may not be final; but if that determination should be confirmed by the whole marine fauna, I will willingly accept the decision, as I have already done in the analogous case of the upper coal seams of Bohemia, where the gas-shale contains Permian animals with a carboniferous flora.

I would next notice some points relating to the lower Gondwana groups, upon which Mr. Blanford's conclusions were rather premature. It will appear—

a.—That the contrast between the floras of the upper and lower groups of the Gondwana system is not so very decided; no more so than between the Jurassic and Triassic formations elsewhere.

b.—That the affinities of our Damuda flora with that of the mesozoic epoch and especially of the triassic formation are overwhelming; and that the arguments for this conclusion are not derived from three species discovered only last year.

c.—That the analogy with the flora of the lower coal strata in Australia is comparatively weak.

a.—*Relation of the floras of the upper and lower Gondwana groups.*

That there is a certain contrast between the flora of the lower and upper portion of the Gondwana Series is, as I think, quite natural, both belonging to distinct formations; the former considered by me Triassic, the latter being Jurassic; but I think the break is not more distinct than between Trias and Lias, or between Trias and Oolite, or even between Rhætic and Oolite in any country.

We find, for instance, scarcely any identical species in the Buntsandstein of the Vosges and in the Lias of the Alps or in the Oolites of England, and we find also no species identical in the Rhætic strata and the Oolitic strata of England.

The triassic strata of the Vosges are, as everybody knows, marked especially by *Schizoneura* and some of the *Coniferous genera* as *Voltzia* and *Albertia*. None of these occur in Lias or Oolite in Europe; and the *Cycads* in the European Trias also are very rare, although not wanting.

Here in India the relation or the passage between the upper and lower portion of the Gondwana Series is palæontologically much better marked—

*a.*—Indirectly, or by the strata themselves, and especially through the Panchet group.

This contains some rhætic fossils, which formation is altogether a transitive group between the Trias and Lias; our Rajmahal beds being of this latter

* Nova Acta Leopoldina Ac. Nat. Curios., Vol. XXII, Part II, p. 456 ff., Pl. 49, f. 2.

† Transact. Geol. Soc., London, Vol. VII, 2nd Ser., p. 175 ff., Pl. XXII, etc.

‡ On South African fossils: Quart. Jour. Geol. Soc., 1867, p. 140 ff., Pls. V—IX.

age.* The Damudas again are closely connected with the Panchet group by that very well marked fossil *Schizoneura Gondwanensis*, Fstm., which is so frequent in both, and which has its only relations in the European Trias.

*b.*—Directly by fossils.—There are several forms which are common to both, or, at least, which are represented in both.

There are amongst the *Tæniopterideæ* two forms which are very near to some from the Rajmahal Hills, *Macrotæniopteris danæoides*† being very near to *Macrot. lata*, O. M., var. *musæfolia*; both occur very frequent; and some other specimens from Kamthi being near, if not identical with *Angiopteridium McClellandi*, O. M., from the Rajmahal Hills. (This we find in Sir Charles Bunbury's paper‡ as *Tæniopt. danæoides?* McClell.) Both these *Tæniopteris* are found together with the common *Glossopteris*.

Amongst the *Pecopterides* there is *Alethopteris Lindleyana*, Royle, and another form, lately brought by Mr. Wood-Mason from Raniganj (see further on), which belong to the same group as the *Alethopteris indica*, O. M., from the Rajmahal Hills; it is to the mesozoic group of *Alethopteris Whitbyensis* Göpp.

*Cycadeaceæ* in the lower groups are also not wanting at all, since we know that there is a *Nœggerathia Hislopi*, Bunb., from several localities, a *Nœggerathia Vosgesiaca*, Bronn, from the Godavari District, and a *Glossozamites* from the Karharbári coal-field. (For these species see further on).

Of course it may be said again that these are genera of wide range, but yet the species are distinct, so is the *Macrotæniopteris lata* and *danæoides* well distinct from *Tæniopt. abnormis* or *Germari* or *multinervis* in the Carboniferous; also *Alethopt. Whitbyensis* and *Lindleyana* from *Alethopt. Serli* or *pteroides* in the Carboniferous; and *Nœggerathia Hislopi* and *Vosgesiaca* from *Nœggerathia foliosa*, Stbg., from the coal-measures.

There are, moreover, all the other mesozoic relations, as *Phyllotheca*, *Actinopteris*, *Sagenopteris*, &c., which are represented in Jura and Rhætic, or in the middle mesozoic epoch of Europe, to which latter the upper portion of our Gondwanas is to be referred.

b—*The affinities of our Damuda flora with that of the mesozoic and especially triassic epoch.*

The first critical discussion of the Damuda flora was given, 1861, by Mr. Oldham§ and later again, 1865,‖ where it was endeavoured to be shown that it had a palæozoic affinity, although Mr. Oldham himself acknowledged the exclusively triassic connection of the so

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* Messrs. Oldham and W. T. Blanford have stated this too. Mr. Blanford (Mem. III, p. 133, Raniganj field) says plainly "that the *Panchet Series* represents a period of time intermediate between that of the other two groups (Damuda and Rajmahal"), and Mr. *Oldham* (l. c., p. 204) says—

"The marked break between the Rajmahal and the Damuda rocks, as proved by the total change in their flora, has now, to a certain extent, been filled up by the establishment of the *Panchet group or sub-division intermediate between the two.*"

† Known already by *Royle* and *McClelland*, later brought from *Burgo*, Raniganj, and lately again from Raniganj.

‡ Quart. Journ. Geolog. Soc., XVII : Flora of Nagpúr.

§ Memoirs, Geological Survey, India, Vol. II, p. 324 *et seq.*

‖ Memoirs, Geological Survey, India, Vol. III, p. 203 *et seq.*

frequent genus *Schizoneura*. Already, 1861, in a paper by Sir Charles Bunbury* (p. 345), strong doubts are expressed as to this supposition, and the flora of Nagpúr and Burdwan considered rather mesozoic.

In the fifteen years which elapsed since that date, the collections have increased greatly, and we have in all the special collections unmistakable evidence for the supposition of M. Bunbury as to the mesozoic, and, as I add, triassic age of the Damuda flora.

Already in the old collections from Raniganj there were proofs enough. There were *Schizoneura* very frequent, there were one or two *Sagenopteris*, Presl., *Glossopteris*, different from those in Australia. From Kamthi there were specimens of *Tæniopteris* (*Macrotæniopteris* and *Angiopteridium*), of distinct real *Phyllotheca*, like that in the Oolites in Italy; there were again a quite different *Glossopteris* from those in Australia, different not only by the shape of the leaf, but especially by the fructification.

In 1871 some fossils with mesozoic and also triassic affinities were brought by Dr. Stoliczka from Karharbári, amongst which *Voltzia heterophylla* and a *Cyclopteris angustifolia*, McCoy, were at that time determined, and amongst which I have recognised a *Sagenopteris* and a distinct *Glossozamites*.

Again in 1873 an *Actinopteris* was obtained from the Raniganj field, and a collection from the lower Godavari contained some triassic affinities in *Nœggerathia Vosgesiaca* and mesozoic affinities in a *Sagenopteris* near *rhoifolia*, Presl. In the season 1873-74, Mr. V. Ball brought from the Satpura Basin the Triassic *Schizoneura*, which was there frequent enough. In 1876 we got some interesting species, which are of great importance as cumulative evidence for the triassic age of our Damudas, especially as they are just from the lowest portion, the Barákar group. These important fossils are from Karharbári, and were presented by Mr. Whitty. They were *Neuropteris valida*, Fstm., *Voltzia heterophylla*, Bgt., *Albertia speciosa*, all triassic forms, and *Gangamopteris cyclopteroides*, Fstm., which is identical with that almost only fossil of the Talchir group, and which has relations in the mesozoic beds in Victoria.

Lately, too, I discovered a real *Phyllotheca*, as that from the Oolites in Italy, amongst the Raniganj fossils. And quite recently Mr. Wood-Mason brought a rather valuable suite of fossils from Raniganj containing further proofs of mesozoic age. I mention especially *Vertebraria*, *Sagenopteris pedunculata*, Fstm.,† *Alethopt. Lindleyana, fructificans*, another *Alethopteris* of the group of *Alethopteris Whitbyensis*, and so on.

To illustrate this relation of our Damuda flora with the mesozoic epoch in general and with the triassic epoch specially, I add here a full list of the fossils, as I know them at present; they are partly contained in my first note, and the description of others are contained in following note, No. VIII; others will be given in the Journal Asiatic Society, Bengal.

## *EQUISETACEÆ.*

1. *Schizoneura Gondwanensis*, Fstm.—Very frequent in the Raniganj group of the Raniganj field and in the corresponding Bijori horizon of the Satpura basin, also in the Panchet group. The only relation is the TRIASSIC *Schizon. paradoxa*, Schimp.,‡ from the Vosges. Never known from Australia.

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* Quart. Jour. Geolog. Soc., XVII: Flora of Nagpúr.

† This and other species of Mr. Wood-Mason's collection will be described in the Journal of the Asiatic Society, Bengal.

‡ The genus *Zengophyllites*, Bgt., which has been confused with *Schizoneura* and of which we find a figure in Strelecki's New South Wales (p. 250, Pl. VI, f. 5), proves by a thorough examination to be a *Zamites* of the genus *Zamites* or *Podozamites*, and quite different from *Schizoneura*; so also *Noggerathia* (W. T. Blanford, l. c., p. 83), is no *Schizoneura*.

2. *Sphenophyllum trizygia*, Royle, sp.—from the Raniganj group, Raniganj field, and from the Barákars of Talchir in Orissa.—Completely different from all palæozoic forms.

3. *Vertebraria indica*, Bunb.—In the whole Damuda Series. Some specimens from Raniganj prove the relation with Triassic *Equisetaceæ*. In Australia only from upper coal-measures.

4. *Phyllotheca indica*, Bunb.—The type form in the Kamthi beds, and a specimen from the Raniganj field. Nearly allied forms in the Italian Oolite, with which Australian forms also are connected.

5. *Other* stems of *Equisetaceous* plants in many places.

## *FILICES.*

6. *Actinopteris Bengalensis*, Fstm.—from Raniganj coal-field. In Europe the genus is in rhætic strata.

7. *Neuropteris valida*, Fstm.—from Karharbári coal-field pretty frequent. The only analogous forms are in the TRIAS of the Vosges; single-pinnate *Neuropteris*.

8. *Alethopteris Lindleyana*, Royle.—from the Raniganj field. One species of the mesozoic group of *Alethopteris Whitbyensis*, Göpp. Lately brought in fructification by Mr. Wood-Mason.

9. *Angiopteridium* comp. *McClellandi*, O. M.—from the Kamthi beds, otherwise in the Rajmahal Series.

10. *Macrotæniopteris danæoides*, Royle, McClell.—from the Raniganj and Jheria fields, pretty frequent, and from Burgo in the Rajmahal Hills (Damudas)—Related with mesozoic forms.

11. *Macrotæniopteris Feddeni, Fstm.—from the Kamthi beds.*

12. *Glossopteris (Tæniopteris ?) musæfolia*, Bunb.—from Kamthi beds, different from any Australian form.

13. *Glossopt.* (*Tæniopteris ?*) *stricta*, Bunb.—from Kamthi beds; not like any in Australia.

14. *Glossopt. indica*, Schimp.—from Raniganj and Kamthi; in the latter place with fructification; the globular *sporanges* in 4-5 rows on the leaf surface. Nothing like this in Australia.

15. *Glossopt. leptoneura*, Bunb.—from the Kamthi beds; an Indian species.

16. *Glossopteris*—many other species—not common with the Australian beds.

17. *Glossopteris Browniana*, Bgt.—I must state that I have never seen a good representative of this species from Indian rocks.

18. *Sagenopteris pedunculata*, Fstm. (*Glossopt. acaulis*, McClell.)—from the Raniganj coal-field, lately brought again by Mr. Wood-Mason. Nothing like that known from Australia.

19. *Sagenopteris* comp. *rhoifolia ?* Presl.—from Kunlacheru in the Godavari District. In Europe in Rhætic.

20. *Sagenopteris Stoliczkana*, Fstm.—from Karharbári coal-field. The genus in Europe is Rhætic and Oolitic. No *Sagenopteris* is known from Australia.

21. *Gangamopteris angustifolia*, McCoy.—from Karharbári coal-field. In Australia in the mesozoic rocks of Victoria.

22. *Gangamopteris cyclopteroides*, Fstm.—from the Barákars in the Karharbári coal-field and from the Talchirs. The genus in Australia occurs in the mesozoic rock of Victoria.

23. *Gangamopteris Whittiana* Fstm. from Raniganj field. The genus is mesozoic.

24. *Belemnopteris Wood-Masoniana*, Fstm.—New genus and new species, from Raniganj field.

25. *Palæovittaria Kurzi*, Fstm., nov. gen. and spec.—from Raniganj field.

*CYCADEACEÆ.*

26. *Nœggerathia Hislopi*, Bunb.—from the Kamthi beds.

27. *Nœggerathia* comp. *Vosgesiaca*, Bronn—from Kunlacheru, Godavari District. This species, to which our specimen is very near, is in Europe known only from triassic beds.

28. *Glossozamites Stoliczkanus*, Fstm.—from Karharbári coal-field. In Europe this genus ranges from Lias to Cretaceous.

*CONIFERÆ.*

29. *Voltzia acutifolia*, Bgt.—from Karharbári.
30. *Voltzia heterophylla*, Bgt.—from Karharbári.
31. *Albertia speciosa*, Schimp.—from Karharbári.

} In Europe the most characteristic species of triassic beds.

From what I have said in this section we can draw the conclusion—

*That the Damuda flora exhibits itself quite decidedly as mesozoic and most naturally as of triassic age, as out of thirty-one species known at present, there are nineteen distinctly mesozoic forms, of which six species evidently triassic, four species of rhætic, and the others of generally mesozoic affinities.*

But also, the other twelve species, amongst which *Glossopteris* is represented by six species, have NO *palæozoic affinities;* and of all the species of *Glossopteris*, only one might be identical with one in Australia.

c.—*What is the analogy of our Damuda Series with the lower coal-measures in Australia?*

This point, as Mr. Blanford truly observes, must be taken into consideration; but the analogy is by no means what he seems to think it.

Any instructive or conclusive comparison can only be made between series that possess fairly represented and characterized flora. For our Damudas this condition can only be said to exist in the upper coal-measures in Australia, and in some exclusively plant-bearing rocks of Europe.

I think those palæontologists who declared the whole Australian flora as absolutely jurassic, did not distinguish the *lower* and *upper* portion of the coal-measures. The first contains forms which could never support this assertion; while the upper measures contain, besides those plants without analogy, some other forms which certainly can justify the supposition of a jurassic age.

On page 83 Mr. Blanford gave a scheme of the formations in the New South Wales coal-field (1, 2, 3, 4, 5, 6). Nos. 1, 2 (Wianamatta and Hawkesbury beds), it is true, have yielded no distinct *Glossopteris;* but in Tasmania, from where identical fossils with those of these two beds are known, *Glossopteris* occurs with *Pecopteris Australis*, *Phyllotheca*, and the most important, with *Tæniopt. Daintreei*, McCoy. (McCoy: Prodrome, Decad. II, p. 15: Report of Progress, Geol. Survey, Victoria, 1874, p. 25).

As to 3 and 4, of which the first are the upper coal-measures of Newcastle, Mr. Blanford himself (p. 83) says, "Nos. 3 and 4 appear to be connected by the presence of *Glossopteris Browniana* in both, although there *appears to be a considerable distinction in the flora*"; and I would add, No. 3 does not contain any animals, while in No. 4 marine animals are found abundantly.*

On page 84 Mr. Blanford enumerates the species, which, as he considers, are common to our Damudas and the Australian beds, and others which are common to the Damudas and the triassic rocks in Europe (as I pointed out). On these I would remark—

*Glossopteris* (two or three species identical, W. T. B.)—I think with great difficulty we may be able to get only one common species.

*Gangamopteris* (the genus only. W. T. B.).—This form is not known at all from those beds intercalated with marine fossils, but from really mesozoic beds in Victoria, associated with *Tæniopteris Daintreei*, McCoy.

*Vertebraria* (one species identical. W. T. B.)—There is as yet no full description of the Australian *Vertebraria*, and that which is known seems to be quite different from ours. The greatest portion of our Damuda *Vertebraria* are probably not identical with those from Australia.

*Pecopteris* (*Alethopteris*) (one species probably identical. W. T. B.)—I doubt whether our *Alethopteris Lindleyana* can be united with *Alethopt. Australis, McCoy; or if this is altogether the case with any other species.*

Thus it seems that the evidence of a connection with the Australian coal-measures is very weak, while the fossils enumerated as common with European Trias are unmistakably identical.

*As to the stratigraphy of the Australian coal strata*—the literature is not poor; but yet it is not in all points quite clear and always trustworthy.

It is well known that there can be a complete concordance in the stratification of rocks, and yet two or more different formations may be represented which can only be distinguished by the prevailing fossil forms. As an instance I can quote the Salt Range in India, where, as Mr. Wynne tells us, the lower marine carboniferous and the triassic rocks are conformably deposited; and yet they are different in age, although a well marked *Ceratites* and *Phylloceras* goes down into the carboniferous rocks, and marked forms of *Belerophon* survived into the Trias. The same relations will have to be applied to the two portions of the Australian coal-measures, only that here the case is illustrated in the flora.

For the stratigraphical grouping of the coal-strata of New South Wales we must especially take Mr. W. B. Clarke's observations, which to a great extent are published:† partly Mr. Clarke communicated them to me in two letters, and he sent also a suite of fossils for

* I speak of this further on.

† Remarks on the Sedimentary Rocks in New South Wales, IIIrd Ed., 1875.

comparison. From all his clear communications it is plain that there are two very distinct portions in the Australian coal-measures—

*a.—Upper coal-measures.*

*b.—Lower coal-measures.*

*a.*—The upper portion is marked by a flora, which is abundant Nos. 1, 2, 3 of Mr. Blanford's list must be referred to this; they contain no marine fossils to indicate a connection with the lower portion.

*b.*—The lower coal-measures are marked by two marine faunas of, as generally taken, a carboniferous age, which separate distinctly these from the upper beds. The flora is, as both Mr. Clarke and Mr. Daintree state, only rare.

*c.*—Below this there are beds with real lower carboniferous plants.

The succession of the several strata of the Australian coal formation, as Mr. Clarke communicated it to me in a late paper, and as it is to be found in his "Remarks" (l. c.), is as follows:—

| | Beds in Tasmania, Queensland, Victoria. Without New South Wales. | |
|---|---|---|
| Upper Coal-measures. | Clarence River.<br>Winamatta beds.<br>Hawkesbery beds.<br>Bowenfels.<br>Upper beds in Newcastle. | No animals. |
| Lower Coal-measures. | Beds with marine animals intercalated with plant beds. Especially Stony Creek, Rix. Ck., Greta, Mnt. Wingen, &c.<br>Again marine beds. | |
| Culm Series | Smith Creek<br>Port Stefens | Lower carboniferous plants with carboniferous animals. |
| Devonian ... | Goonoo-Goonoo | Plant remains only. |

As to the fossils from these several beds I may give an account of those which I have seen, or which are mentioned as really occurring—

*a.—Upper coal-measures—*

1. From Queensland: *Pecopt. odontopteroides*,* Morr., *Tæniopteris Daintreei*, *Cyclopt. cuneata*, Carr., &c.

   These beds are altogether taken by Daintree as mesozoic, and *Tæniopt. Daintreei*, characteristic of these beds.

2. From Tasmania—prevailing *Thinnfeldia*-like ferns; besides this *Glossopteris* and *Pecopteris Australis*, McCoy.

3. From Victoria—from here we find the following plants described as mesozoic†:—

   *Gangamopteris angustifolia*, McCoy, *G. spathulata*, *Gangam. obliqua*, McCoy, *Neuropteris* sp.

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* I should say this is rather a *Thinnfeldia*.

† See Report of Progress, Geolog. Surv. of Victoria, p. 35.

*Pecopteris Australis*, McCoy., *Sphenopteris*, *Tæniopteris Daintreei*, McCoy., *Zamites ellipticus*, McCoy.

*Phyllotheca Australis*, McCoy.—Here we have real *Phyllotheca* with *Tæniopt. Daintreei*. McCoy.

4. From the Wianamatta and Hawkesbery, we have mostly *Dichopteris*, *Thinnfeldia*, *Pecopteris odontopteroides*. Morr., *Tæniopteris*, etc.; and in both the same genus of a fish.

5. From Clarence River District.—*Tæniopteris* with narrow leaves, and a coniferous branch, to which Mr. Clarke himself marked ?*Voltzia*.

6. Bowenfels and Newcastle.—Here the flora is mostly developed: *Vertebraria*, real *Phyllotheca*, many *Glossopteris* (but very few identical with those of India), mostly *Gloss. Browniana*, Bgt., coniferous plants near the mesozoic *Echinostrobus*, coniferous seed-vessels and others, but *no animal fossils*, nor lower carboniferous plants.

*b.—Lower coal-measures*—

I have seen *Tæniopteris* near *Tæniopt. Eckardi*, Germ., *Glossopteris*, small specimens: besides these, there are quoted *Phyllotheca* and *Nœggerathia*. With these are associated carboniferous fossils.

*c.—Strata below*—with *Cyclostigma Kiltorkanum*, Haught., *Rhacopteris*, *Sphenophyllum* (real palæozoic form). These I have seen myself. And again a palæozoic (carboniferous) fauna.

From this we see the following:—Only the strata sub. *b* can claim a palæozoic age, containing a prevailingly carboniferous fauna, which already in *c* occurs together with a palæozoic flora. The flora in *b* is very poor, containing only few forms, which* are so frequent in the upper strata; and to use Mr. Clarke's words about the *Glossopteris*, we may say: "There (in the Australian lower coal-beds) it clearly does not govern, but must be subordinate to the fauna;" and further he says, "why might it (*Glossopteris*) not pass into secondary rocks without denying its existence in the Australian lower coal-measures"?

In the last publication, Mines and Minerals of New South Wales, there is a Supplementary Report by Mr. John Mackenzie on the New South Wales coal-fields, in which on Section *b*, is a sketch-section from Newcastle to Port Booral, about thirty miles long. In this the difference in the fossil remains of the upper and lower portions of the coal-measures is plainly indicated, and also that the upper portion and lower portion are, besides all the differences, slightly discordant.

This may be enough for the present paper; some more material would clear off the matter still better. But already from this we see that there is a great difference between *the upper and lower portions of the coal-measures in Australia, the former containing only flora of mesozoic affinities, the latter prevailingly a carboniferous fauna, by which they are in connection with the beds below, although some plant forms begin in them, which* afterwards are much more developed; but no *Schizoneura*, no single-pinnate *Neuropteris*, no *Sagenopteris*, no *Voltzia*, no *Albertia*, etc., are found.

Our Damuda flora could, at all events, only be compared with this upper portion, and only through the *Glossopteris* and *Vertebraria*, our flora being much more numerous. But, as I have said, there is perhaps only *one* species common; the Australian *Vertebraria* seems to differ from ours, and the *Phyllotheca* in Australia is as well related

* Remarks, etc., p. 165.

with ours as with that from the Italian Oolite, while in our Damuda flora all the other plants are mesozoic and most of them triassic.

That the upper beds in Australia—Wianamatta, Hawkesbery—and the upper Newcastle coal-beds form a connected series is also shown by the occurrence of the same fish, which is not found in the lower strata.

The following table may illustrate the relations :—

| Europe. | | Lower Gondwanas in India. | Coal-measures in Australia. |
|---|---|---|---|
| Rhæt. ... / Keuper ... | *Upper Trias* ... | Panchet group. (Flora and Reptilia). | a. *Upper coal-measures.* All the strata, as I enumerated them above under 1, 2, 3, 4, 5, 6. *Flora only.* |
| Grès bigarré / Bunt.-Sanst. | *Lower Trias* ... | Damuda group. Flora only. | |
| Carboniferous ... | ... | ... ... | b. *Lower coal-measures.* |
| Carboniferous ... | ... | ... ... | *Strata below.* |
| Devonian ? ... | ... | ... ... | *Goonoo-Goonoo.* |

## VII.—Flora of the Jabalpúr group in South Rewah, near Jabalpúr, and in the Satpura basin.

The Jabalpúr group, as indicated in a former note (*ante*, p. 29), is that upper portion of the Gondwana series covering a large area in South Rewah and also in the Satpuras, the two being almost continuously connected by a narrow outcrop skirting the intervening area of overlying trap, and passing through Jabalpúr at the head of the Narbada valley. It derives its name from the place where its fossil plants were first and best known, *i. e.*, Jabalpúr.

Although the stone in which the plants are preserved differs in each of the three positions just named, the fossils themselves do not, plainly showing that we have to deal with but one formation. These beds were formerly placed on a common horizon with those of Rajmahal and Kach; but, as I have already indicated, these must be separated into two groups, an older typified by the Rajmahal group (in the Rajmahal Hills and near Golapili, Godavari District), and a newer containing the Kach series, to which the Jabalpúr group belongs, the fossils of both being identical.

The fact of the Kach and the Jabalpúr strata being placed with the Rajmahal group, which has long since been recognised as most probably Liassic, would, however, show that from the first the fossil plants of Kach have not been considered of so young an age as has lately been inferred from some of the associated marine fossils. When I examined the Kach flora I was not acquainted with that of the Jabalpúr group; but although geographically intermediate between Kach and Rajmahal, and thus presumably likely to exhibit a blending of the flora had there been any community of horizon, as was formerly supposed, the Jabalpúr flora is specifically the same as that of Kach, and confirms the conclusions I had arrived at regarding the age of the rocks. Some recent discoveries in the Godavari region,* where Jabalpúr plants have been found together with reptilian remains and liassic fishes, tend to support those conclusions, as opposed to the impression made from the *Cephalopoda* of the Kach strata.

* Hughes. s

The flora of the Jabalpúr group is more numerous than that of the Kach beds, but it exhibits the same character and some of the same peculiarities. I will proceed now to describe the plant remains.

### *A.—EQUISETACEÆ.*

As in Kach, we find also in the Jabalpúr group a complete want of any plants of this order; but I think the jurassic period, above the lias, did not, on the whole, abound in equisetaceous plants, the scarcity of them also marking the whole cretaceous epoch until they become again more frequent in the tertiary rocks

Even in our liassic Rajmahal group the equisetaceous plants were very rare and represented only by *Equisetum Rajmahalense*, Schimp., from the Rajmahal Hills; while in the Panchet group and Damuda series the frequence of equisetaceous plants is represented by the very triassic *Schizoneura*, Schimp.

### *B.—FILICES.*

In the Jabalpúr group ferns are much more frequent than in Kach, and altogether better preserved, the rock being less sandy and micaceous. With the new species I will give a short diagnosis and will indicate shortly the relations, not omitting relations with older fossils than jurassic.

#### I.—SPHENOPTERIDES.

There is only one species closely allied to a form in Europe only known in the oolite.

1.—*Sphenopteris arguta*, Lindl. and Hutt.

There is little doubt that our specimen must be referred to this species, its greater size only made me hesitate to identify it completely, but the whole habit and form of the leaf, &c., agree. From the Satpura basin.

#### II.—NEUROPTERIDES.

None of the real *Neuropteris* have been found, but there is another plant which is generally brought in connection with *Neuropterides;* it is a *Cyclopteris*, Bgt., and belongs to that division, distinguished by the name *Baiera*, Braun., which does not indicate more than a mesozoic *Cyclopteris*, Bgt.

1.—*Cyclopteris lobata*, Fstm. [Compar. *Cyclopt.* (*Bajera*) *digitata*, L. and H.]

*Folia semicircularia, basi emarginata, cordata (?) margine lobate, lobis (laciniis) ut videtur denticulatis ; nervis e basi foliorum radiatim usque ad marginem eggredientibus, dichotomis, ramulis repetito furcatis.*

This species already considered by Dr. Oldham a *Cyclopteris* belongs indeed to this genus in the real sense of Brongniart's *Cyclopteris*, of which some mesozoic forms were subsequently ranged with *Baiera*, Br.; while those specimens from the Rajmahal Hills, which I have called *Cyclopteris Oldhami*, Fstm.,* belong to the sub-genus *Cordiopteris*, Schimp.

Our specimen from Jabalpúr resembles that form described by Dr. Schenk as *Dicranopteris Rømeri*, Schenk,† which is also a *Cyclopteris* and from rhætic beds. The only difference I see is in the slightly thinner veins. On the other hand it is scarcely to be distinguished from *Cyclopt.* (*Baiera*) *digitata*, L. and H., from the lower oolite in England; especially Lindley and Hutton, pl. 63, f. 1, and Brongniart, Hist. d. végét., tab. 61 bis., f. 2. Our specimen seems to me not to be so deeply lobed.

* Records, Geol. Surv., Ind., 1876, Vol. IX, 2 p. 35.

† Flora der Grenzschichten, &c., 1867, p. 145, Pl. XXI, f. 9.

### III.—PECOPTERIDES.

This family is pretty frequently represented; it also occurs both in Kach and in the Rajmahal series.

*Group of Alethopteris Whitbyensis*, Göpp.

Two forms represent this group, which is essentially lower jurassic.

1.—*Alethopteris Medlicottiana*, Oldh.

*Fronde tripinata, pinnis remotis patentibus, pinnulis integris, striatis; e basi latiore lanceolatis, acuminates basi paulum subdecurrentibus, fere contingentibus. Nervo medio distincto, nervis secundariis sub angulo acuto aggredientibus dichotomis.*—(Diagnosis given by me).

This specimen was recognised already by Dr. Oldham as differing from the others of this group. He proposed the name as above, which I will not change, although it has never been published, and I find it only in pencil on the original drawing.

Our species differs from the allied forms in the *pinnulæ*, which begin with a broad base, but become much narrower, giving the whole plant a peculiar appearance; it may be closely allied with *Pecopt. ligata*, Phill.*

2.—*Alethopteris Whitbyensis*, Göpp.

This species we know already from *Kach*; in the present region it is more common and especially in the form described formerly by Brongniart as *Pecopteris tenuis*,† which has, however, already been united by Unger and others with *Alethopteris Whitbyensis*, Göpp.

As I have said, M. Schimper‡ placed all these related forms to the group *Alethopteris Whitbyensis*, Göpp., considering it a truly jurassic type.

Mr. Saporta has done the same; only he established for all these allied forms a new genus, *Cladophlebis*, Sap., which would then contain the following species:—

*Alethopteris Rösserti, Aleth. Whitbyensis, dentata, Phillipsi, harburnensis, arguta, recentior, nebbensis, &c., &c.*, establishing for all these a close relation, as I have shown in my Kach flora.

Our specimens of *Alethopt. Whitbyensis*, Göpp., are from the Satpura basin.

3.—*Pecopteris comp. Murrayana*, Bgt.

A specimen from Jabalpúr recalls this lower oolitic species. I found the same determination written by Dr. Oldham on the original drawing, which I will use in my detailed paper.

Of the *Pecopterides*, therefore, *all three species indicate* a lower oolitic age. One is also found in Kach.

### IV.—TÆNIOPTERIDES.

Only some fragments represent this family, indicating one of those forms which Schimper placed in his subgenus *Macrotæniopteris*, reserving *Tæniopteris* for the *Palæozoic* forms; amongst these, however, are also some which could be taken as *Macrotæniopteris*, Schimp. I only recall the specimen described thirty years ago by Gutbier as

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* Phillips' Geology of Yorkshire, III Edit., Pl. VIII, f. 74.

† Hist. d. végét. foss., 1828, Pl. 110, f. 1.

‡ Trait. de Pal. végét., 1869, Vol. I, p. 560, &c.

*Tæniopteris abnormis*, Gutb.,* and which also Schimper has placed with *Tæniopteris*, Bgt. But Dr. Sterzel† in Chemnitz, finding this species very closely allied with the rhætic *Macrot. gigantea*, Schenk., and with the liassic species from the Rajmahal Hills [*Macrot. lata*, Oldh. Mor., *Macrot. Musæfolia*, Oldh. Mor. (not Bunbury), and *Macrot. Morrisi*, Oldh. (only partly)] has regarded it also as *Macrotæniopteris*, Schimp. Dr. Sterzel says about these species, so closely allied with *Tæniopt. abnormis*, Gutb., that there is scarcely any difference and only the formation separates them. For me it is a great satisfaction to see forms, which I have declared to be liassic, so nearly related with a *Permian* one. The close relationship of *Macrot. lata*, Oldh. Mor., from the Rajmahal Hills with *Macrot. gigantea*, Schenk., from rhætic, I mentioned already in my first note,‡ and will discuss it more closely in my Rajmahal Flora.

Altogether, *Macrotæniopteris*, Schimp., contains mostly representatives of lower jurassic forms.

1.—*Macrotæniopteris Satpurensis*, Fstm.

*Fronde latissima, ut videtur tenera; nervis secundariis approximatis, rectissimis, plurimis indivisis non nullis solum furcatis.*

Our specimen is quite fragmentary—only a portion of the leaf-surface is preserved,—but the veins are so peculiar that it can be distinguished by this character—of course scarcely as a peculiar species, only as a variety; it is rather related with those forms described from the Rajmahal Hills, which differ only in having the venation more separated.

Our specimen is from the *Satpura basin.*

## V.—Dictyopterides.

### *Genus:* Sagenopteris, *Bgt.*

1.—*Sagenopteris comp. Phillipsi*, Lindl. & Hutt.

Lindley and Hutton first described this species as *Glossopt. Phillipsi*,§ while Prof. Phillips has mentioned it as *Pecopt. paucifolia*.|| In his last edition of the Geology of Yorkshire, however, he uses the name *Glossopteris Phillipsi*, L. & H. In M. Brongniart's Hist. d. vég., pl. 63, f. 2, we find also two figures of *Glossopt. Phillipsi*, L. & H., agreeing only with Phillip's figure (III. edit., pl. VIII); and both of these differ from Lindley and Hutton's original figure.¶

Later, Brongniart's and Phillip's figures have been correctly placed by Schenk and Schimper again in *Sagenopteris*, Bgt.,** as *Sagenopt. Phillipsi*, Schenk.,†† where Lindley and Hutton's variety is to be placed also. But Schimper does not mention that *Sagenopteris* begins, as is known, in the rhætic and continues in the lower oolite.

Lately I succeeded in getting some species of *Sagenopteris* out of the Damudas, one of which is strikingly near to *Sagenopt. rhoifolia*, Presl., from rhætic (see further on).

* Guthier: Versteiner ungen, etc., 1837, I, p. 71-73.
† Jahrb. f. Min. Geol. Palæont., 1876, Uber die Tæniopteriden v. Chemnitz, p. 369, etc., pl. v, vi.
‡ Rec. Geol Surv. Ind., 1876, N. II.
§ Foss. Flora of Gr. Brit., Vol. I, pl. 63.
|| Geology of Yorkshire, I and II edit., Tab. VIII, f. 8.
¶ Vol. I, pl. 63.
** Flora der Grenzschichten, p. 104.
†† Also Count Casp. Sternberg in Fl. d. Vorw. II., p. 165, knew the name *Sagenopt.*.

From the Jabalpúr group there is a *pinna*, of which the veins are disposed in the same manner as in *Sagenopt. Phillipsi*, especially in Brongniart's figure 2, tab. 63 (Hist.). Our specimen is narrower and longer, the midrib quite distinct, the secondary veins passing out of it at an acute angle, are once or twice dichotomous, and join again quite close to the margin. From *Jabalpúr.*

In considering the ferns found in the Jabalpúr group, we have mostly such forms as are found in Europe in the lower oolite, thus:

1.—*Sphenopteris* comp. *arguta*, L. & H.—In England a lower oolitic species.

2.—*Cyclopteris lobata*, Fstm.—Nearly identical with *Cyclopteris digitata*, L. & H., which is lower oolitic in England.

3.—*Alethopteris Whitbyensis*, Göpp.—A lower oolitic species in England.

4.—*Pecopteris* comp. *Murrayana*, Bgt.—In England a lower oolitic species.

5.—*Sagenopteris* comp. *Phillipsi*, Schenk.—A lower oolitic species in Europe.

## C.—CYCADEACEÆ.

In the Jabalpúr group we find the *Cycadeaceæ* pretty abundant, more so than in Kach, and with other genera; but here again the genus *Ptilophyllum*, Morr., is found.

Some of the species are true lower oolitic forms; one is liassic.

### I.—Zamieæ.

This family alone is represented in the Jabalpúr group, but very frequently. I shall use the generic names as Schimper used them in his Paléont. végétale, and as they are also generally acknowledged.

1.—*Podozamites* (*Zamia-Zamites*) *lanceolatus*, L. H.*

There occur very many detached leaves, long and lanceolate, angustate a little at their base, acuminate on their apex, and with numerous veins. They are identical with *Zamia lanceolata*,† L. & H., or *Podozamites lanceolatus*, Schimp.‡

This is a lower oolitic species, where it has the same place and importance that *Podozamites distans*, Presl.§ has in the rhætic; the veins of the latter, however, are rarer and thicker.

We know this species from all three districts—South Rewah, Jabalpúr, and Satpura basin.

2.—*Podozamites spathulatus*, Fstm.

*Foliis brevioribus, ovato lanceolatis, basi attenuatis, spathulatis, nervis paucis, simplicibus.*

This form is shorter, ovate towards the apex, and the veins are more distant from each other; in this character this species approaches more to *Podoz. distans*, Presl., of the rhætic. From South Rewah—

3.—*Podozamites Hacketi*, Fstm.

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* Foss. Flora of Gr. Brit, Vol. III., pl. 194.

† Trait. d. Pal. végét., Vol. II, p. 159.

‡ Presl. in Sternberg Ver. II, p. 196, Tab. 41, f 1; Schenk. Flor. d. Grenzschichten, p. 159, Tab. 35, f. 10, etc. Schimper Pal. végét., Vol. II, p. 160.

*Fronde latiuscula, rhachide crassiore, foliolis (pinnis) approximatis, oblonge lanceolatis, acuminatis, basi angustatis, suboppositis, oblique insertis, nervis creberrimis, ut videtur simplicibus; media in parte costa subdistincta longitudinali e basi usque ad apicem currente.*

Two specimens of this species have been brought by Mr. Hacket, which differ from the former in the arrangement of the leaves, their form, the rigidity and disposition of the veins.

Our specimens are so closely allied to Mr. McCoy's *Podozamites Barklyi*,* that the want of a decurrent leaf-base and the presence of but one longitudinal rib constitute the only difference. By the want of the decurrent leaf-base our specimens have less resemblance to an *Araucaria* (or *Bowenia*) than Mr. McCoy's. (See *loco cit.*)

The Australian species is from the Bellarine beds (Victoria), which Mr. McCoy considers as mesozoic (oolitic), in which I think he is right.

Our specimens are from the Satpura basin, and are named after Mr. Hacket (of our Survey), who collected them. It is of importance.

1.—*Otozamites Hislopi* (Oldham sp.) Fstm.

(*Zamites Hislopi*) Oldh.,—label on specimen.)

The genus *Otozamites* is frequent enough in the Jabalpúr group, together with *Ptilophyllum*, Morr. The species above is a very good one, and has been named so by Dr. Oldham himself, for which reason I have kept the specific name, placing it among *Otozamites* to which it appears properly to belong. There is, however, no description of this species anywhere. The name is written only with pencil on the label of the specimen. The diagnosis I give myself.

*Foliis latiusculis, apicem versus attenuatis; rhachide ut videtur tenui; pinnis rhachidis superficiem tegentibus, alternantibus, basi latioribus, apicemque versus attenuantibus, apice paulo sursum incurvatis obtusis; basi obtuse auriculata, indistincta cordata, puncto uno tantum inserta ; nervis e basi radiatim in folia currentibus, distincte repetito furcatis.*

In the form of the leaf-base and in the manner of insertion, it resembles quite closely *Otozamites Goldiæi*. Bgt.,† but the leaves are much shorter and more obtuse.

In the Kach flora I have described one form as very near to *Otoz. Goldiæi*, Bgt., from Kukurbit; it may stand between our *Otoz. Hislopi*, Oldh. sp., and the true *Otozamites Goldiæi*, Bgt.

Our specimen is from the Sher river, Satpura basin.

Besides this species there are several other species of *Otozamites*, Br., of which I will only mention one as important.

2.—*Otozamites* comp. *gracilis* (Kurr sp.) Schimp.

Kurr described this species first as *Zamites gracilis*;‡ it is from the schist with *Posidonia* of the Upper Lias near Ohmden in Wurtemberg.

Schimper described it as *Otozamites*, and this is the only species with which he could compare our *Ptilophyllum*. He says in his Paléontologie végétale: " *Cette espèce rappelle*

* Prodromus of the Pal of Victoria, Decade I, p. 33, Pl. VIII. f. 1, 2, 5.

† Saporta: Végét foss. de France, Paleontologie franç. Pl. XCV. f. 1, from lower oolite in England, Yorkshire.

‡ Kurr: Beitrage zur Flora der Jurat. Wurtembergs, 1845, p. 11, pl. 1, f. 4.

*un peu le genre Ptilophyllum des Indes.*"* And we have this liassic species in our Jabalpúr group, which is of the same age as the Kach series.

There are about three or four specimens which closely resemble *Ptilophyllum cutchense*, Morr.; but they have no decurrent leaflets; the base of the leaflets is a little broader, sub-auricled, and subcordate, attached by the middle of the base only, the veins radiating in the leaflets, and forked within; the leaflets closely set, alternating, having evidently all the characters of *Otozamites*, Br., in which class Schimper has therefore rightly placed it. Dr. Oldham had already determined it correctly.

It still further proves the early age of our Jabalpúr and Kach series. Our specimens are from the Sher river in the Satpura basin.

1.—*Ptilophyllum*, Morr. (*Palæozamia*, *Endl.*).

This common genus of the upper portion of the Gondwana series occurs, and shows again the relation of this group with the others as belonging to the same epoch. *Ptiloph. acutifolium*, Morr., is the prevailing form.

The only related form of *Ptilophyllum*, Schimper finds, as I mentioned, with the liassic *Otozamites gracilis* (Kurr.), Schimp., and just this genus is the most prevailing and most characteristic of the upper portion of the Gondwana series.

Our specimens of *Ptilophyllum* are from *Satpura basin*.

1.—*Williamsonia conf. gigas*, Carr.†

I have had occasion to mention this interesting and important genus from the Kach series, the Rajmahal series in the Rajmahal Hills, and from Golapili. It occurs also in the Jabalpúr group.

In pl. 53, f. 15, Mr. Williamson gives a section of the restored *involucrum*, with smooth pyriform axis supporting a superficial layer of oblong cells arranged vertically on its outer surface, and with this our specimen from the Jabalpúr group agrees quite well, only that the layer of cells seems to be broader in the upper part. Outside, several of the lanceolate scales are well seen. I will range our specimens provisionally as *Williamsonia* comp. *gigas*, Carr. From the Satpura basin.

We have therefore amongst the *Cycadeaceæ* the following species of great importance:

1.—*Podozamites lanceolatus*, L. & H. sp. Very frequent in all three districts; a lower oolitic species in England; represented in the rhætic by *Podozam. distans*, Presl.

2.—*Podozamites Hacketi*, Fstm., from the Satpura basin. Nearly identical with the Australian *Podoz. Barklyi*, McCoy from mesozoic (oolite).

3.—*Otozamites comp. gracilis*, Kurr.,‡ from the Satpura basin. In Europe an upper liassic form, related a little to *Ptilophyllum*, Morr.

4.—*Ptilophyllum acutifolium*, Morr., from the Satpura basin. Prevailing in the Rajmahal series.

5.—*Williamsonia comp, gigas*, Carr., from the Satpura basin. In England specially a lower oolotic species.

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* Vol II., p. 171.

† Williamson: Transact. Linn. Soc. Vol XXVI, Pl. 52, 53. Carruthers Transact Linn. Soc., Vol. XXVI.

‡ Also Dr. Oldham determined it to be this species.

## *D.—CONIFERÆ.*

In this class are again some very typical lower oolitic plants, as we have found also in Kach; one species expressing the relation of these beds with the other members of the upper portion of the Gondwana series.

1.—*Palissya indica*, Fstm.( Oldh. & Morr. sp.).*

*Ramis distichis alternantibus, foliatis, foliis linearibus patentibus alternis, in pulvinulo decurrentibus distinctissime sessilibus nervo distincto e basi uno sulcis duobus profundioribus limitato* (fonctificatione non obvia).

Of the same plant which Dr. Oldham and Prof. Morris figured from the Rajmahal Hills, and which I found later among the Kach flora and from Golapili, some very good specimens occur also in the Jabalpúr group, one of which MM. Oldham and Morris figured already in their Rajmahal Flora (l. c.) as *Taxodites indicus*, O. & M. But later Dr. Oldham himself recognised it to be a *Palissya*, and I will use his specific name. But as MM. Oldham and Morris have given no diagnosis, nor any description, I supply the want. It is very near to *Palissya Brauni*, Endl., from the rhætic. From the Satpura basin.

2.—*Palissya Jabalpurensis*, Fstm.

*Ramis distichis (?); crassioribus foliorum pulvinulis tectis ramulis foliatis: foliis æqualibus, oblonge lanceolato-ovalibus, patentibus, remotiusculis: basi constrictis, distincte decurrentibus, pulvinulis oblongis insidentibus: nervo ut videtur unico medio. Amentis in certis.*

This species is very characteristic of the Jabalpúr group, and, till now, known only in it; it has the same importance here as *Palissya conferta*, Fstm., in the Rajmahal series. Through this species and one other coniferous plant (*Auracartites Kachensis*, Fstm.), I have recognised the *Ceratodus* beds of the Godavari region as belonging to our Jabulpúr group.† From Jabalpúr.

3.—*Brachyphyllum mamillare*, L. & H.

I take this fossil in the sense of Lindley and Hutton ‡, who figured on Pl. 188 and 219 two specimens. Mr. Schimper thought these forms different from that described by Brongniart and called the British species *Brachyphyllum Phillipsi*. Schimp §, still I take these specimens to be *Brachyphyllum mamillare*, L. & H.

Our specimens are pretty frequent and do not differ in anything from the English lower oolitic species. Dr. Oldham himself has already written on the figures of some specimens, which I found drawn, the determination: *Brachyphyllum mamillare*, L. & H., which they really are. From Jabalpúr.

4.—*Echinostrobus expansus*, Schimp.

Of this species, so frequent in Kach, several specimens occur. One specially is very well preserved, showing a pretty large branch with branchlets and the characteristic leaves. It is much more complete than any of those from Kach, and, I should say, than any of those figured. While our specimens from Kach agree more with Phillips' figures ||, this specimen from the Jabulpúr group agrees better with Sternberg's¶

* *Taxodites indicus*, Oldh., Morr Rajm Flora, Pl XXXIII. f. 6 -Figure only.

† See Mr Hughes Rec Geolog Sur. Ind, 1876, N III.

‡ Foss. Flor of Gr. Brit., Pl. 188, 219.

§ Palæontol végét., II. Vol., p. 336.

|| Geology of Yorkshire, ed III. Ed. pl x. f. n.

¶ Vers einer Fl. d Vorw. I. Tab. 38, f. 1. 2.

From South Rewah and the Satpura basin.

5.—*Araucarites Kachensis*, Fstm.

I gave this name to seeds which were pretty frequent among the Kach fossils and which are very closely allied to Mr. Phillips' "Winged seed,"* described later by Carruthers as belonging to *Araucarites*, with the name *Araucar, Phillipsi*, Carr.† Those from Kach I called *Araucarites Kachensis*, Fstm.,‡ in order to distinguish them, although they are very like those from England. In the Jabalpúr group they also occur very frequently, and they are the same as in Kach, so that I shall call them by the same name.

Besides *Palissya Jabalpurensis*, Fstm., Mr. Hughes found this species in the Wurdha coal-field, near Nawgaon. I was, therefore, able to determine this group with certainty.

From South Rewah, Jabalpúr, and the Satpura basin.

Besides these species mentioned, there occur some more coniferous plants that seem to be peculiar, although allied with one or the other of those described.

Amongst the coniferous plants there are, therefore—

1.—*Palissya indica*, Fstm.—an Indian type.

2.—*Palissya Jabalpurensis*, Fstm., characteristic of the group.

3.—*Brachyphyllum mamillare*, L. & H.

4.—*Echinostrobus expansus*, Schimp.

5.—*Araucarites Kachensis*, Fstm.—the three last are lower oolitic forms in England and elsewhere.

Altogether I have now mentioned nineteen species of fossil plants, which may rise to about twenty-four or a little more when I add the species as yet not mentioned. I would here only discuss those that are best determined and correctly compared with other well known forms.

From these nineteen mentioned species there are—

*a*.—Identical or very closely allied with English lower oolitic species—

1.—*Cyclopteris lobata*. Fstm.,—scarcely different from *Cyclopteris Baiera digitata*, L. & H.

2.—*Alethopteris Whitbyensis*, Göpp.

3.—*Pecopteris Murrayana*, Bgt.

4.—*Sagenopteris comp.*, Phillips, Schenk.

5.—*Sphenopteris comp.* arguta, L. & H.

6.—*Podozamites lanceolatus*, L. & H.

7.—*Williamsonia comp. gigas*, Carr.

8.—*Brachyphyllum mamillare*, L. & H.

9.—*Echinostrobus expansus*, Schimp.

10.—*Araucarites Kachensis*, Fstm., near *Araucar. Phillipsi*, Carr.

Of the other nine species there are—

*b*.—An upper liassic form:—

1.—*Otozamites gracilis*, Kurrsp.—from Upper Lias near Ohmden in Wurtemberg—the only ally of our *Ptilophyllum*, Morr.

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* Geology of Yorkshire, II. Edition, Pl., x., f. 5.
† Carruthers, Geolog. Magaz., 1869, Vol. VI., p. 6, Pl. II, f. 7—9.
‡ Kach Flora, Palæontol. Indica, 1876.

*c.*—An Australian type :—

1.—*Podozamites Hacketi,* Fstm.—strikingly close to *Podoz. Barklyi,* McCoy—from Ballarine Rocks (Mesozoic—Oolitic) in Australia.

*d.*—Two species are Indian types :—

1.—*Ptilophyllum acutifolium,* Morr.—in the whole range of the Upper Gondwana series.

2.—*Palissya indica,* Fstm.—common in the upper portion of the Gondwana series, as in Kach, and in the Rajmahal Hills and Golapili.

*e.—One species is peculiar to the group.*

1.—*Palissya Jabalpurensis,* Fstm. Known only in these beds.

There are therefore—

10 species lower oolitic.
1 upper liassic.
2 of Indian types.
1 characteristic of the group.
1 Australian (oolitic) type.

The other four are peculiar, but more or less allied with those already mentioned.

If we compare this flora with the other Indian local floras, it has the nearest relation with that of Kach.

Species identical with those in Kach—

1. *Alethopteris Whitbyensis,* Göpp.
2. *Ptilophyllum acutifolium,* Morr.
3. *Williamsonia,* Carr. genus.
4. *Palissya indica,* Fstm.
5. *Echinostrobus expansus,* Schimp.
6. *Araucarites Kachensis,* Fstm. (abundant).

Species identical with those of the Rajmahal series—

1. *Sphenopteris arguta,* L. & H. (an oolitic species).
2. *Ptilophyllum acutifolium,* Morr. (Indian type).
3. *Williamsonia,* Carr. genus.
4. *Palissya indica,* Fstm. (Indian tpye).

Species identical with those in the beds with *Ceratodus,* &c, in the Godavari region; only two species have been found, and both are Jabalpúr forms—

1. *Palissya Jabalpurensis,* Fstm.
2. *Araucarites Kachensis,* Fstm.

From these considerations the following conclusions may, I think, be drawn :—

1. The prevailing fossils are essentially of such kind as we find generally in lower oolite, agreeing with those from Yorkshire; we will therefore have to consider our Jabalpúr group also of the same age. This conclusion is strengthened—

2. By the occurrence of one distinctly liassic species, *Otozamites gracilis,* Kurr sp.

3. By the occurrence of the same group in the Wurdha coal-field with fish and reptilian remains, hitherto believed to be liassic.

4. Amongst the Indian local floras that of the Jabalpúr group has most species common with the Kach flora, suggesting their close correspondence as to age, so that—

5. All conclusions which can be arrived at about the age of the Jabalpúr group may so far be also applied to the Kach series.

Remains of *Lepidotus* and of *Hyperodapedon* have also been found in the *Ceratodus* beds, indicating the same liassic formation.

In a greyish-red fine sandstone beneath the *Ceratodus* beds of Kota Mr. King found some plant remains which I think to be *Palissya conferta*, Fstm. This species being characteristic of the Rajmahal series, it would seem that this horizon also may be distinguishable in that region.

I may here remark that from a cursory inspection I have made of the Kach collections, I do not think they will bear out the inferences based upon the *Cephalopoda* as to the Tithonian horizon of the upper members of the series.

## VIII.—Descriptions of new and discussions of some already known but important species from the Gondwana Series.*

In the following pages are given the descriptions of some new species, which to the date of the publication of my former papers were not known to me, although for some years in our collections. During the thorough rearrangement of the Museum they have been found, and prove very important for further evidence as to the determination of age. Also some species, which were already formerly known, but which occur again in better specimens.

### *A.—A new Rhætic form of Pterophyllum*, Bgt., in the *Rajmahal Hills.*

Amongst those species which are described by Oldham and Morris,† we find already one form which approaches a rhætic species (*i. e.*, *Pteroph. Princeps*, O. M., very near to *Pt. Braunsi*, Sch.); another has even connections in the Permian formation.

I have now to report on another rhætic species—

*Pterophyllum* comp. *propinquum*, Göpp.

1844. Goppert · Uber foss. Cycadeen, etc. Verh. d. Schles. Gesellsch., p 132 ff., Tab. I, f 5.
1867. Schenk : Flora der Grenzsch., p. 215.

In the above quoted paper Mr. Göppert described a true *Pterophyllum*, Göpp., which is especially remarkable by the distant, pretty equal leaflets, passing out from the *Rhachis* nearly quite straightly. He designated it first as from jurassic rocks, which, however, afterwards proved to be rhætic (in consequence of the examinations of Mr. Schenk and F. Rimer).

Amongst the specimens of the older collections of Rajmahal plants in our Museum, there is a (rather fragmentary) specimen, which by the form and disposition of the leaflets can be compared only with *Pterophyllum propinquum*, Göpp I cannot discuss it further

* I think it necessary to join these descriptions here in a short form, as I refer to the species in the preceding pages; they will, however, be described and figured more closely in the special papers on the local floras.
† Palæontol. Indica, 1862: Flora of the Rajmahal Series in the Rajmahal Series.

*better specimens of a real Phyllotheca from the Kamthi beds, and also one specimen from the Raniganj coal-field.*

Sir C. Bunbury called this Indian *Phyllotheca Ph. Indica*;† but it is related to the *Phyll.* from the UPPER coal-fields in Australia,‡ I mean the beds above the first marine fauna; and both are related with the *Phyllotheca* of M. de Zigno§ in the Italian Oolite.

Nothing like this is known in the Permian. This and the coal epoch have their own equisetaceous plants. The Permian epoch has been rather poor in equisetaceous plants, while *it is known that the* Trias period produced them again very abundantly; in this also our Damuda series agree with the Trias.

The occurrence of the same real *Phyllotheca* (*Ph. Indica*, Bunb.) has not till now been mentioned anywhere from the Raniganj coal-field; lately I discovered one specimen of this species.

The great abundance of equisetaceous plants in the Damudas, with prevailing *Schizoneura*, a triassic genus, and with occurrence of the real *Phyllotheca*, so frequent in the Italian Oolite, would therefore again indicate rather a mesozoic (triassic) age.

The same *Phyllotheca Australis*, McCoy, is also known from Victoria together with *Tæniopteris Daintreei*, McCoy, which latter in Queensland is considered as characteristic of the mesozoic (upper) coal beds.||

2.—*Tæniopterides of the Damudas and their connexions.*¶

In my preliminary paper, mentioned above, I have already called attention to some distinct forms of *Tæniopteris*, Bgt., which should indicate a connection between the Damudas and the Rajmahal Series. Since that time I have examined some other specimens, which prove this connection still more, which I will discuss now.**

*a.*—That species which Sir C. Bunbury figured l. c. Pl. X, f. 2, with the name *Tæniopteris Danæoides* (?) McClell., is not, I think, correctly placed. I have got some other specimens identical with this figure, but they are no *Tæniopt. danæoides*†† (McClell.—Royle.)

* Records Geol. Surv. Ind., 1876, N. 3, p. 63 ff.

† Quart. Jour. Geol. Soc., XVII, p. 335, Pls. X and XI.

‡ McCoy: Annals of Nat. Hist., Vol. 20, p. 152 f.

§ Zigno: Flor. foss. form. Oolith., Pls. VII, VIII.

|| Daintree (and Carruthers) on the Geology of Queensland. Quar. Jour. Geol. Soc., 1872.

¶ See further on the note on Mr. Wood-Mason's fossils.

** Mr. Hughes assured me several times that he brought some nice specimens of *Tæniopteris danæoides*, McClell., from *Raniganj*, but I never could find them in our collections.

†† Royle: Illustr. Bot. and oth. Nat. Hist. Him. Mount., Tab. 2: McClelland: Report, 1848-49, Tab. 15.

Schimper * has shown another and perhaps more natural place for it; he took it as synonymous with *Tæniopt. McClellandi*, O. M., which he placed in his genus *Angiopteridium*, Schimp. This view becomes quite probable if we compare Sir C. Bunbury's drawing (l. c.) with *Tæniopt. McClellandi*, O. M.;† and the other specimens before me seem to confirm the determination.

Sir C. Bunbury's specimens as well as ours are from *Kamthi*.

*b.*—Besides this there are from the Nagpúr district (Kamthi) several specimens of a much bigger *Tæniopteris* (*Macrotæniopteris*) which have some related forms, but which yet seem to be different.

The top portion recalls especially *Tæniopteris lata*, O. M., l. c., Pl. IV. f. 3. Pl. V. f. 2. But it belongs to the specimens with which it occurred. It recalls also a little Sir C. Bunbury's *Glossopteris musæfolia*, Bunb., l. c. It would agree quite well, only that there are no *anastomoses* at the base of the veins in our specimens, which Sir C. Bunbury states to have observed.

I therefore cannot identify the specimens under discussion with one or the other species mentioned, as there are differences enough to establish a new species, which I will describe as following:—

MACROTÆNIOPTERIS FEDDENI, Fstm.

*Fronde simplici speciosissima usque 20 cm. lata, ut videtur, ovato-elongato-elliptica; apice obtusa, quando que emarginata, plerumque irregulariter incisa vel divisa, consistentia subcoriacea, costa in proportione ad frondis latitudinem ac magnitudinem tantum crassiuscula longitudinaliter striata compressa; nervis secundariis creberrimis tenuibus summa in parte (apicem versus) sub angulo acute egredientibus, marginemque versus plus sursum arcuatis; in parte frondis inferiore fere horizontalibus marginem versus paulo tantum sursum incurvatis simplicibus ac furcatis alternantibus furcatione aut in ipsa basi aut quodam in parte longitudinis nervorum exhibita.*

I have named this very interesting species after Mr. F. Fedden of our Survey, who collected it some years ago in *Kamthi*.

Our species holds a middle place between the Permian *Tæniopt.* (*Macrot.*) *abnormis*, Gutb., and the three species of *Macrotæniopteris* from the Rajmahal Hills, and we have, therefore, in our Triassic beds, between the Permian and Jurassic, a *Macrotæniopteris*.

We have, therefore, the following species of *Tæniopteris* in our Damudas—

*Tæniopteris* comp. *McClellandi*, O. M., from Kamthi. Sir C. Bunbury's *Tæniopt. Danæoides?* should be placed here—a Rajmahal species.

*Macrotæniopteris Danæoides*, McCl., (Royle)‡, from Burdwan (Royle) from Jherra coal-field (Hughes) and from Raniganj, and from Burgo in the Rajmahal Hills (our coll.).

*Macrotæniopt. Feddeni*, Fstm., the broadest form I know.—From Kamthi.

If we compare the two *Macrotæniopterides* of the Damudas with the Permian and the Rajmahal forms, we have the following series (regarding the distance of the veins):—

1. *Macrotæniopteris Danæoides*, McCl.—Damuda.—(The widest distance.)
2. *Macrot. lata*, O. M.—Rajmahal Hills.
3. *Macrot. Feddeni*, Fstm.—Damuda.
4. *Macrot. abnormis*, Gutb. Permian.—(The narrowest distance).

* Paléont. végét., Vol. I, page 605.
† Rajmahal Flora, (Oldham and Morris), Pl. XXIII, figs. 1, 2, 3.
‡ See further Mr. Wood-Mason's collection.

### 3.—*A new Gangamopteris from the Kamthi beds and another from Karharbári.*

Of the genus *Gangamopteris*, which McCoy established for some transitious forms between *Cyclopteris* and *Glossopteris*, I described already one species in my first note on the flora of the Damudas and the Talchir group: I called it *Gangamopt. cyclopteroides*, Fstm.,* on account of the more *Cyclopteris*-like form of the leaf. From the occurrence of this species both in the Barákar and Talchir groups, I draw the conclusion that these groups are both of the same age, as the Talchir group contained little else than this species McCoy described it first from some rocks in Victoria, where no marine fossils occur, but where *Tæniopteris Daintreei*, McCoy, is found, which latter in Queensland is considered as characteristic of the mesozoic beds there. With these also *Phyllotheca Australis*, McCoy, occurred in Victoria.

Now I have also from the *Kamthi* beds very closely allied forms;† they are, however, much smaller, seem to have a thicker substance, thicker veins and wider venations, so that I will describe it as a species of its own. Another species, brought lately by Mr. Wood-Mason, I mention further in the note on the fossils he brought from Raniganj.

GANGAMOPTERIS HUGHESI, Fstm.

*Fronde simplici, rotunde ovali, sub coriacea basi ut videtur subcordata, margine intergra, mediocriter longa, maximo specimine* 10-11 *cm. longa*, 5 *cm. lato; rhachide vel nervo medio nullo; nervis radiatim e basi usque ad marginem currentibus, arcuatis, nonnulis mediis, omnibus parte inferiori crascioribus, dehinc omnibus repetito furcatis anastomosantibus retia latiora, breviora formantibus.*

I have called this form after Mr. Hughes of our Survey, who has already collected a great many of interesting fossils from the Damuda series.

Although describing this fossil by a name of its own, I yet believe it related with that species from the lower Damudas and the Talchir group, *i. e.*, *Gangamopt. cyclopteroides*, Fstm.

This again supports, what I have already supposed, that all the three sub-groups of the Damudas, although in reality existing, are yet of the same age, and that the Talchir group too is to be subnamed in this epoch.

Another form must be noticed from the *Karharbári* coal-field, it is—

GANGAMOPTERIS ANGUSTIFOLIA, McCoy.

18 . *Cyclopteris angustifolia*, McCoy Annals and Magaz of Nat. Hist, Vol 20

18 . *Gangamopteris angustifolia*, McCoy · Prodrome of Palæontology of Victoria Dos.

Amongst those specimens which, as I already mentioned several times, Dr. Stoliczka brought from *Karharbári* coal-field, is also a specimen which already at that time was determined as *Cyclopt. angustifolia*, McCoy, which, however, is now by McCoy himself ranged with *Gangamopteris*, McCoy.

This *Gangamopteris* is in Victoria found in certainly mesozoic rocks, being associated with *Tæniopteris Daintreei*, McCoy, which is characteristic of mesozoic rocks in Queensland.‡

* Records Geol. Surv. Ind., 1876, N. 3

† In my last paper on *Damuda* fossils (Rec Geol. Surv. Ind., 1876, N. 3) there is wrongly written "that the specimens from Kamptı belong to the same species" (as *Gangamopteris cyclopteroides*, Fstm.). It should be written that they belong to the same "*genus*"

‡ Daintree. Geology of Queensland, Quar. Jour. Geol. Soc., 1872.

4.—*Some other species of Sagenopteris from the Damudas.*

The two species of *Gangamopteris* described above from the Damuda Series are distinctly belonging to that genus. But there are from the Damudas near Kunlacheru in the Godavari district two specimens, about which I am not quite sure whether they belong also to this genus or whether they are rather to be ranged with *Sagenopteris*, Bgt. They recall, it is true, somewhat *Gangamopteris angustifolia*, McCoy,* but I am not sure if this species too has not rather its place in *Sagenopteris*, Bgt. I for my part take those specimens from Kunlacheru as very near to *Sagenopteris rhoifolia*, Presl., as there is scarcely any difference between them and the leaves of this species when they are detached. We have only to compare the detached leaf in Mr Schenk's Grenzschichten, Pl. XII, f. 4, with our specimens and we find no difference.

Another locality of *Sagenopteris*, Bgt., is the Karharbári coal-field, the same wherefrom I enumerated already four species of mesozoic and triassic age. There is a collection of Karharbári plants in our Museum since the year 1871, and Dr. Stoliczka collected them. Fern leaves are very frequent, with an evidently anastomosing venation, which, however, does not pass out from a midrib; the shape and the association of the leaves on the rock urge us to consider the leaves as detached ones, which formerly have been attached to one common stalk. They are, as I suppose, evidently *Sagenopteris*, but differing in shape and size from those hitherto described. I describe them as follows :—

SAGENOPTERIS STOLICZKANA,

*Fronde digitata ; foliis singulis pedicello communi insertis, deciduis, lanceolato spathulatis,* 10 *cm. longis,* 35 *mm. latis, basi latiusculis, sine pedunculo distincto ; lateralibus ut videtur in forma differentibus, nervo medio indistincto, nervis secundariis sub angulo acutissimo ad marginem currentibus repetito dichotomis, retia formantibus ; retibus inferiore ac medio parte majoribus, marginem versus, minoribus. Fructificatione non obvia.*

The leaves of this species differ in shape and size as well from *Sag. rhoifolia*, Presl., as from *Sag. Göppertiana*, Zign., but it is allied with both, being a *Sagenopteris.*

I will not make any further discussions here—I will only say that the genus *Sagenopteris* in Europe is known only in Rhætic and Lias, and that it has some connection with *Cheropteris*, Kurr., of the Keuper.

Perhaps also some species of *Glossopteris*, Bgt., are allied; I mention, for instance, *Glossopteris acaulis*, McClell., which should evidently be placed here, and I mentioned it already as *Sagenopteris*, Bgt. The *Tæniopteris*, Bgt., with the real mesozoic aspect and with connections in the Rajmahal Series would support the conclusions to be drawn from the occurrence of *Sagenopteris*, Bgt.

Mr. W. T. Blanford is certainly right in saying that some of these ferns are of wide range; but if we consider it nearer it should be said of the most fossils; but I think also of widely ranged genera some species can be characteristic, and this is especially with the *Tæniopteris* the case, even so with *Sagenopteris* and others, and if some of those genera mentioned are of wide range, it is certainly the more the case with *Glossopteris*, so that there yet remain for the Damudas the other species as—

*Macrotæniopteris Danæoides*, McClell., certainly mesozoic, frequent.
*Schizoneura Gondwanensis*, Fstm. (very frequent.)
*Sagenopteris*, two species—Rhætic genus.
*Neuropteris valida*, Fstm.—(frequent.)
*Voltzia acutifolia* and *Albertia speciosa*, Schimp.

* McCoy : Prodrome of the Pal. of Vict., II Decade, Pl. XIII, figs. 2,

*On the four latter of these I will only remark that they in Europe are of triassic age.* To these I add now a fifth—

*Voltzia heterophylla*, Bgt., 1828.

1828. Brongniart: Prodrome.

1828. Histoire des végét. foss.

1843. Schimper and Mougeot: Monograf.

1870. Schimper: Paléont. végét.

Amongst the specimens brought by Dr. Stoliczka from Karharbári are also three, which are labelled *Voltzia heterophylla*, Bgt. I cannot know by whom the label was written, but it is certain that already, five years ago, this species was recognized, but since that time, no doubt overlooked. It is the more important, as this species is just from the lower part of the Damudas, *i. e.*, from the Barákar group.*

This species, as every body knows, is the most characteristic of the Trias, of course in Europe only; but I for my part do not give up the same age for it here in India also.

The discovery and determination of this plant agrees very well with those I later made quite independently, as I found the *Voltzia heterophylla*, Bgt., which Dr. Stoliczka brought, after I had written my first paper on the Damuda fossils.

As far as I know, there is nothing known like these or similar plants from the lower coal-measures in Australia, and also in the upper portion is, besides *Glossopteris*, (a genus of wide range) only *Phyllotheca* and the doubtful *Vertebraria* in common with our Damudas, of which, however, the first genus is also in the Oolite of Italy pretty frequent, and the other Damuda fossils have also abundantly representatives in the mesozoic formations of Europe.

So that with the same probability we can suppose a communication with Europe at that early date of Indian life, and this for the whole period from Trias till Oolite.

### 5.—Cycadeous Plants in the Damudas.

#### *A.—Species of Nœggerathia*, Stbg.

Already Sir C. Bunbury† described from *Kamthi* a species with the name *Nœggerathia Hislopi*, B., of which he knew several specimens, but only one is figured.

*Nœggerathia* was formerly, as were many fossils, a disputed genus; but already Sir C. Bunbury (1861) himself took it rather as belonging to the *Cycadeaceæ*, as I think is now generally acknowledged; and we have in *Nœggerathia* a genus belonging to the *Zamiæ*. I will speak, therefore, first of Bunbury's species.

1. *Nœggerathia Hislopi*, Bunb.

1861. Quar. Jour. Geol. Soc., Vol. XVII, p. 334, Pl. X, f. 5.

Sir C. Bunbury has figured only one specimen, which is rather fragmentary, from Bharat-wádá. From this locality also several specimens are in our collection. All descriptions, as Bunbury has given them, I can confirm. We have several fragments, from which I can judge that the leaves have been about 14 cm. long, beginning with a narrow base and becoming wider towards the apex, where the leaf is apparently oblique.

From another locality in the Nagpúr district, from Barkoi, there is a specimen of the same *Nœggerathia Hislopi*, Bunb., in our collection, which plainly shows that the described

* Of the Survey classification.

† Quart. Jour. Geol. Soc., XVII, p. 334, Pl. X, f. 5.

leaves are only detached and formerly belonged to a common stalk. The specimen mentioned shows two leaves, about 9 cm. long, of the shape as Bunbury described; they are in the same direction lying on one side of a stalk which undoubtedly belongs to these leaves. They were, therefore, attached in the same way as in the real *Nœggerathia;* and if we look for a mesozoic *Nœggerathia*, we find the same arrangement of leaves in the *Nœggerathia Vosgesiacia** Bronn., from the Keuper of the Raibl beds.

Also from the Karharbári coal-field there is one specimen which is to be ranged here.

The leaves of *N. Hislopi*, Bunb., differ from *N. Vosgesiaca*, Bronn. by much stronger veins and by having the margin entire.

*Locality.*—We have this species, therefore, from Bharat-wádá Barkoi, and from Karharbári coal-field.

2.—*Nœggerathia* comp. *Vosgesiaca*, Bronn.

1858. Leonhard and Bronn: N. Jahrb., p. 129, Pl. VI, f. 1-4.
1870-72. Macropterygium Bronni, Schimp.: Pal. végét., Vol. II, p. 132.

There is also another *Nœggerathia* from the *Damudas* of Kunlacheru (Godavari District), which from the first moment I recognized to be a *Nœggerathia;* some incised and lacerated leaves with very fine venation are joined on one common stalk, which, however, is partly broken off, so that I was in doubt about the insertion.

The best, and perhaps only, connection of our specimen I found, however, with Bronn's *Nœggerathia Vosgesiaca* (l. c.) The author described his species as consisting of a pretty large form with a thick stalk, from which passed out on both sides (partly alternating) the leaves, marked by two characters—

1.—By their fine venation, and

2.—That they are not entire, but divided and incised in different manners and degrees, so that they consist of several *laciniœ* joined together.

All these characters our specimen above mentioned exhibits too, so that I can only bring it in close connection with that triassic species.

The middle *laciniœ* of our leaf are 12 cm. long, the marginal ones only 5·6 cm. The general form is cuneiform, the venation very fine, running radially towards the margin, frequently forked, but the branchlets not much thinner than the main branches. Bronn's drawings do not show this forcation, although Bronn himself describes it.

*B.—Another Zamiœ from the Damudas.*

Amongst the specimens brought by Dr. Stoliczka there is still another leaf which by the whole form indicates a *Zamiœ*. It can, however, not be referred to *Nœggerathia*, the leaf base being quite different, from which it follows that the insertion also differed; we have no stalk, but the leaf is only a little attenuated at the base; it reminds strikingly the genus *Glossozamites*, Schimp†. I have no doubt that ours belongs to it.

* Bronn: Zur triasischen Fauna und Flora der bituminösen Schiefer von Raibl, N. Jahrb. für Min. Geol. und Pal., etc., 1858, p. 129. Pl. VI, f. 1-4

† Schimper. Pal. végét. Vol., II, p. 163.

GLOSSOZAMITES STOLICZKANUS. *Fstm.*

*Frondis forma ac magnitudo ignota. Foliis elongato ovalibus, validis 8 cm. longis, 23 mm latis, media parte latissimis, parte apicali paulo attenuata, rotundata, parte basali æquali modo angustata, truncata, angulis basalibus obtusis; foliis media in parte insertis; nervis creberrimis, distinctis, e tota basi radiantibus, furcatis.*

This species has its allies in some forms described by Mr. Schimper with this generic name, but which altogether range only from Lias to lower cretaceous. These species are *Glossozamites oblongifolius*, Kurr.,* from Lias in Würtemberg; *Glossoz. Zitteli, Hoheneggerei*, and *obovatus*, Schenk†.

Our specimen has all the characters of these described species. The largest species till now described is *Glossoz. Zitteli*, Schenk, from lower cretaceous; the leaves measuring 5 cm. 3 mm., while ours are much larger still.

*Locality.*—Karharbári coal-field, brought in 1871 by Dr. Stoliczka, in the same coal-field from where *Neuropteris valida*, Fstm., *Voltzia heterophyllum*, Bgt., *Voltz. acutifolia*, Bgt., and *Albertia speciosa*, Schimp, are known by Mr. Whitty's discovery.

There is, therefore, no want of *Cycadeous plants* in the *Damudas*, and they are mostly of mesozoic character.

All these supplementary notes were, I think, necessary; and it is probable that still more plants of this kind will be discovered to finally establish the position I have indicated for their formations.

MR. WOOD-MASON'S COLLECTION OF FOSSIL PLANTS FROM RANIGANJ.

I cannot omit giving a short note on some very interesting plants Mr. Wood-Mason lately has brought from Raniganj. They not only exhibit better specimens of already known species, but to a great extent also new forms. As at Mr. Wood-Mason's request I shall write a special paper on them, only a very short note shall be given here.

*Macrotæniopteris (Tæniopteris) Danæoides*, McClell. (Royle).

The same species which Royle formerly called *Glossopt. Danæoides*, but later McClelland correctly described as *Tæniopteris Danæoides*, McClell., of which he gave two figures, and of which there is a nice specimen in our collection from Burgo in the Rajmahal Hills‡ (Damuda beds), Mr. Wood-Mason found several very nice and well preserved specimens; and his statement is, that this form is there very frequent. All the specimens have a very mesozoic aspect, and strikingly resemble certain specimens from the Lias (Keuper?) in the Alps. Besides this they resemble also pretty much *Tæniopt. lata*, O. M., especially the specimen Pl. II, f. 1, and the variety *Tæniopt. musæfolia*, O. M , Pl. IV, f. 1, from the Rajmahal Hills; again also a further evidence of connection of both portions (upper and lower) of the Gondwana Series.

Gen. *Glossopteris*, Bgt., and *Sagenopteris*, Presl.

Mr. Wood-Mason has brought various specimens of the common Raniganj forms, with narrow net-venations, which I will describe as *Glossopt. communis*, Fstm. But besides these two or three leaves of that species which McClelland called *Glossopteris acaulis*, but which I referred to *Sagenopteris*, Bgt. (as *Sagenopt. pedunculata*, Fstm.)

* Kurr.: Beitr. zur. jura formation Würtembergs, p. 12, tab. I, f. 5, 1846.

† Schenk. Foss. Fl. d. Nordkapathen. Palæontogr, Vol. XIX (1871), tab. I, II, III.

‡ Some nice specimens were, as *Mr. Hughes* has several times assured me, brought by him from the *Raniganj* field, but I never could find them in our collections.

Gen. *Gangamopteris*, McCoy.

I have described already two species from our Damudas, i. e., *Gangamopt. cyclopteroides*, Fstm.,* and *Gang. Hughesi*, Fstm.† Mr. Wood-Mason brought also another, which differs from both by the much wider net-venation, which is also pretty constant in the size of the meshes of the net. I will describe it later with the name *Gangamopteris Whittiana*, Fstm., after Mr. Whitty, who contributed so much last year to our knowledge of the Karharbári flora by the magnificent slab of shale, covered with fine plant-impressions, contributed by him to our museum. I must still once more state that the Australian *Gangamopteris* is from mesozoic strata in Victoria, together with *Tæniopt. Daintreei*, McCoy.‡

BELEMNOPTERIS, *nov. gen.*, Fstm.

Amongst the ferns there is a wonderful specimen, which has its very close connection with the living *Pteris sagittæfolia*, Raddi§, and *Hemionitis cordata*, Roxb. Mr. Wood-Mason's specimen has the same arrow-like shape; three primary veins, the chief primary veins stronger and more distinct; the secondary veins form a net-work of prevailingly hexagonal meshes. This specimen belongs to quite a new fossil genus which I call as above. The species I call in honor of Mr. Wood-Mason, *Belemnopteris Wood-Masoniana*, Fstm. Descriptions and discussions will be given later with the figure of the specimen.

Of other *ferns* there is especially remarkable a very nice large specimen of an *Alethopteris* form of the type of the living *Phegopteris*, a fructificating pinna of *Alethopt. Lindleyana*, Royle, which belongs also to this group.

PALÆOVITTARIA, *nov. gen.*, Fstm.

*Another new genus.* Of much interest is another specimen with about eleven or twelve leaves coming out (as it seems) from a common spot; the leaves have the form of the mesozoic *Sagenopteris*, Bgt.; they have an evanishing midrib (towards the apex); the *secondary* veins have nearly the same direction, but form *no net-work*, a circumstance which I think will establish this form as a new *genus*, as it cannot be well united with *Tæniopteris*, Bgt.

I do not know anything in the fossil Flora closely similar with it. In the form of the leaves and their disposition there is an approaching similarity with *Næggerathia spathulata*, Dana,‖ from Australia, but there the veins all are radiary, without any midrib.

There is also a slight resemblance with *Chiropteris* from the Keuper¶; but the shape of the leaves, the direction and disposition of the veins, the total want of a distinct *rachis*, and the presence of several thicker veins, distinguish *Chiropteris* from our fern.

I already now can say it is a new genus, allied only with the living *Vittaria*—so that I will call it *Palæovittaria* n. g., and the species *Palæov. Kurzi*, Fstm.

Of other plants I have still to mention several nice specimens of the *Sphenophyllum trizygia*, Ung., which all show again the great difference of the Damuda forms from those in the coal-measures.

These plants, brought by Mr. Wood-Mason, add considerably to our knowledge of the Damuda flora, and have especially yielded again strong evidence of its mesozoic age.

* Rec. Geol. Surv. India, IX, 3.

† Present paper.

‡ This species Mr. Daintree himself takes as characteristic of the *mesozoic* of Queensland.

§ Ettingshausen: Farren der Jetztwelt, 1865, Pl. 71, f. 3.

‖ Dana: Geology, United States Exploring Expedition, Pl. 12, f. 9.

¶ Bronn: Uber die Farrengattung *Chiropteris*, Kurr. etc., N. Jahrb., f. m. 1858, p. 143, Pl. XII.

To give a complete idea of the flora and its connections, I have given in the preceding Note a general list of all the fossil remains I have so far had occasion to mention from the Damuda beds, which themselves may indicate the age of these beds. I hope there will be added still more of them, but yet these are the most important now, and establish sufficiently the age of the series.

## NOTES ON THE OSTEOLOGY OF MERYCOPOTAMUS DISSIMILIS, BY R. LYDEKKER, B. A., *Geological Survey of India.*

*Previous notices.*—Of this extinct genus of Hippopotamoid Artiodactyla, which is confined to the Tertiary Strata of India and Burma, no complete descriptions of any part of the skeleton, beyond the teeth, have hitherto appeared. Figures of the cranium, and of some of the limb-bones, have, however, been given in the "Fauna Antique Sivalensis" (*plates* 67 *and* 68), and a short notice of the cranium was given by Dr. Falconer and Sir Proby Cautley in the Asiatic Researches (*vol. XIX*). This paper, together with figures, will be found reprinted in the "Palæontological Memoirs" (*vol. I, p.* 138). In the same volume (*p.* 147, *plate* 15 *figs.* 1 and 2) there is also given a short notice with figures of an adolescent cranium from Burma, forwarded by Dr. Oldham to Dr. Falconer: this specimen is now in the Indian Museum. Professor Owen (*Odontography p.* 566) has also given a figure and a short description of the general characters of the molar teeth; a molar tooth is also figured in M. De Blainville's Osteographie (*Atlas Anoplotherium*); M. Pictet (*Paléontologie, vol.* 1, *p.* 342) has classed the genus, chiefly on account of the form of its molar teeth, with the *Anoplotheridæ*. In Dr. Falconer's above-quoted paper the species was placed in the genus *Hippopotamus*, In the collection of the Indian Museum we have fragmentary portions of several of the limb-bones, from the Manchhars, Siwaliks and Burma beds. From the examination of these, together with Falconer's figures, I have been enabled to arrive at an approximate idea of the skeleton of the genus, though many parts are still wanting, which I hope subsequent discoveries will make good.

*Character.*—*Merycopotamus* seems to have been a tetradactyle animal of about the size of the Indian wild boar; its dentition has the same formula as in the latter animal, and the excessive development of the canines in both jaws is a character common to the fossil form, to the allied living genera *Sus* and *Hippopotamus*, and to the fossil *Anthracotherium*. The femur followed the normal *Artiodactyle* rule of lacking a third trochanter for the glutæus maximus; while the cuboid and navicular bones of the tarsus were distinct, and the facets on the astragalus for the articulation of these two bones, were of nearly equal size. The radius and ulna were disunited, as in the *Pig*, while in the *Hippopotamus* they are anchylosed together. It will be found that the extinct genus presents points in common with both *Sus*, *Hippopotamus* and *Anthracotherium*, and may probably be regarded as having, like the latter genus, formed a connecting link between the *Suina* and *Ruminantia*. As its name implies, the form of its molar teeth approaches that of the *Ruminantia*, and breaks down the distinction between the "cylindriform" teeth of the true *Pecora*, and the "columno-agglomerate" teeth of the *Suina*: in the Siwalik period, however, these two groups of *Artiodactyla* had already been completely differentiated: we cannot, therefore, consider *Merycopotamus* to have been in any way a progenitor of the true *Ruminants*, but the genus may very probably have descended from some older form which at an earlier period diverged from an original stock allied to the *Suina*, and gave rise to the more modern and specialized group of *Ruminantia*. From the dimensions of the axis vertebra, *Merycopotamus* must have been a much longer-necked animal than either the *Pig* or the *Hippopotamus*, in this respect also showing · tendencies.

*Cranium.*—My examination of the cranium has been chiefly confined to the young specimen from Burma noticed above, which from the state of the sutures is in a very favourable state for comparison. The general form of the skull somewhat resembles that of *Hippopotamus*, especially in the long even slope from the occipital crest to the extremity of the nasals, and in the comparatively slight depth of the upper portion of the cranium; the wide zygomatic arches and the deep and sharp sagittal crest are also *Hippopotamine* characters. The muzzle is slightly expanded at its extremity, but not to the same enormous extent as in *Hippopotamus*.

*Orbits.*—The orbits are approximately circular, and completely surrounded by a bony ring; their superior borders are somewhat produced and elevated, forming the highest points on the forehead, while the frontals are considerably depressed below them; in all the above characters the skull of *Merycopotamus* agrees closely with that of *Hippopotamus*, and differs from that of *Sus*. The orbit is placed unusually far forwards, so that its inferior border is directly over the hinder barrel of the first molar: the distal articulation of the jugal reaches as far forwards as the first premolar. In *Hippopotamus* the inferior border of the orbit is placed over the hinder barrel of the second molar, and in *Sus* over the middle of the last molar.

*Nasals.*—The proximal extremity of the nasals does not extend upwards to within half-an-inch of the inferior border of the orbit; in this respect the skull more resembles that of *Sus*, since in *Hippopotamus* the proximal extremity of the nasals extends upwards beyond the centre of the orbits. The distal extremity of the nasals differs from that of both *Hippopotamus* and *Sus*; in *Merycopotamus* the nasals diminish in width very gradually from above downwards, and terminate somewhat above the extremity of the muzzle; their distal extremity is cut into by an acute re-entering angle; in *Hippopotamus* the nasals narrow very rapidly and terminate directly over the muzzle with a considerable expansion; in *Sus* the nasals narrow gradually and terminate slightly above the muzzle in a pointed extremity. The facial surfaces of the nasals are nearly flat, and placed at right angles to the lateral surfaces of the maxillæ, as in *Sus*; the nasals of *Hippopotamus* are rounded transversely on the facial surface, and do not form any marked angle at their junction with the maxillæ. The greater portion of the outer border of the nasals articulates with the maxilla, and only a very small moiety with the premaxilla; this character forms a marked distinction from *Sus*, and agrees with *Hippopotamus*, only in the latter a rather longer proportion of the nasals articulates with the premaxilla than in *Merycopotamus*; the extremely small proportion of the premaxilla which articulates with the nasals in the latter genus is owing to the relative shortness of the latter bones. The naso-maxillary suture is nearly straight, and thereby different from the same suture in both the allied genera; no portion of the premaxilla overlaps the facial surface of the nasals, as occurs in *Sus*, as distinguished from *Hippopotamus*.

*Maxilla and Jugal.*—The lateral surface of the maxilla is somewhat hollowed; the foramen for the fifth nerve is placed directly over the last premolar, as in *Sus*; it is situated more anteriorly in *Hippopotamus*. The outer surfaces of the molar teeth are placed so far apart, that the jugal for a long distance along its posterior border becomes continuous with the lateral surface of the maxilla, and does not overhang the latter as is the case in *Hippopotamus* and *Sus*. There is no distinct process of the maxilla for articulation with the jugal, on account of the junction of nearly the whole of the posterior surface of the latter with the maxilla; the form of this portion of the skull is quite peculiar to *Merycopotamus*; the form of the union between the squamosal and jugal is not known.

*Lachrymal.*—The facial portion of the lachrymal is oblong in shape, and its surface is quite plane; it is considerably elongated antero-posteriorly, so that it articulates with four bones, *viz.*, the frontal, nasal, maxilla, and jugal As far as I can make out from the skull of *Hippopotamus* with which I have compared this specimen, in the latter genus the lachrymal articulates with the same four bones, but not quite in the same proportions; in *Sus*, on the other hand, we have a very different relationship of these bones; owing to the shortness of the lachrymal and nasals, these bones do not articulate with each other; but between the two a process of the frontal extends downwards to articulate with the maxilla,—a union which does not occur in either *Hippopotamus* or *Merycopotamus.* The lachrymal foramen is single, and pierces the orbital portion of the lachrymal close to the angle separating the former from the facial portion, a condition intermediate between *Sus* and *Hippopotamus;* the fossils do not, of course, show whether the lachrymal formed a thin capsule within the orbit as in the latter genus.

*Frontals.*—These bones are depressed, and are united by a straight sagittal suture,—simple inferiorly, but with interlocking processes superiorly; the distal extremity of the frontals forms a slight re-entering angle for the articulation of the nasals; the naso-frontal suture is deeply indented; a small process is given off from the frontals, which is wedged in between the lachrymal and the nasals; in front of the orbits the frontals seem to have been somewhat expanded laterally, but do not form the "telescopic" orbits of *Hippopotamus;* their form was probably more like that of *Sus.* The venous foramina on the surface of the frontals are situated above the centre of the orbits, and pierce the bone at right angles, somewhat as in *Hippopotamus;* in *Sus* these foramina perforate the bone obliquely, and have long sulci below them.

*Parietals.*—The fronto-parietal suture is not shown in any of the known skulls; the two bones at their union form a bold sagittal crest which divides at its lower third, and runs to the superior angles of the orbits; the surfaces of the temporal fossæ are somewhat convex. The hinder portion of the parietals is very greatly longer in proportion to the size of the skull in *Merycopotamus* than in *Hippopotamus:* the sagittal crest in the former is a long straight ridge for a considerable distance, whereas in the latter it bifurcates to join the orbits after a very short distance. This greater length of the cranial portion of the skull quite does away with the relative excessive length of the nasals, which forms such a remarkable feature in the skull of *Hippopotamus.*

In *Merycopotamus* the cranial and facial portions of the skull are approximately equal, (see plate 67, fig. 5. "Fauna Antiqua Sivalensis"), and from the long sagittal crest the whole cranium has much more the appearance of the cranium of a *Carnivore* than of *Hippopotamus.* In *Merycopotamus* the lateral boundaries of the temporal fossæ are in the same antero-posterior line with the lateral borders of the orbits, whereas in *Hippopotamus* the latter reach outwards to the zygomatic arches.

:*t.*—The form of the occipital surface approaches nearer to that of *Sus* than *Hippopotamus*; the occipital crest forms a bold ridge, angulated in the centre, and somewhat overhanging the general surface of the supra-occipital. The breadth of the supra-occipital is less in proportion to its height than in *Hippopotamus*, and thereby approaches to *Sus:* further, the occipital surfaces of the squamosals are placed considerably more in advance of the plane of the supra-occipital than in *Hippopotamus*, thereby giving the latter bone a more prominent and isolated character, similar to that of *Sus.* The bony ridge connecting the extremity of the occipital crest with the zygomatic process of the squamosal is placed somewhat higher up on the occipital surface, and is larger and stouter than in *Sus:* the prominence of the zygomatic process of the squamosal which overhangs the meatus auditorius externus is wanting in *Merycopotamus.* The supra-occipital is an oblong bone, with its superior extremity produced into a median angle; the ex-occipitals and paramastoid processes are in too damaged a condition in our specimens for comparison. The basi-occipital is triangular in shape; it is more rounded from side to side than in *Sus*, but it lacks the median groove and the two tubercles which are found on the same bone in *Hippopotamus*.

*Bulla tympani.*—There is a large somewhat ovate tympanic bulla, larger than that of *Hippopotamus*, and more like that of *Sus*: the meatus auditorius externus is apparently tubular, and directed upwards, backwards, and outwards.

*Palate.*—The palatines are produced backwards behind the last molar in the same manner as in *Hippopotamus*; their hamular processes have also the same shape and direction; the palato-maxillary suture, as far as I can make it out, seems to have extended as far as the line which divides the first and the second molars; its upward bend is rounded, as in *Sus*: in *Hippopotamus* it is elongated. The two lines of molar teeth are nearly parallel, as in *Sus*; they do not diverge anteriorly, as in *Hippopotamus*.

*Glenoid cavity.*—The glenoid cavity of the squamosal is flat, and of large size; it has no process of the jugal bordering its outer side; in the latter respect it agrees with *Hippopotamus* and differs from *Sus*.

*Mandible.*—The rami of the mandible are nearly straight: the distal extremity is rounded off: the symphysis is long, and slightly excavated; it extends backwards as far as the first premolar; it is somewhat expanded at the alveolus of the canine tooth; the condyle and ascending portion is not known: the posterior extremity descends below the inferior border of the horizontal portion, as in *Hippopotamus*; there is a deep notch in front of the descending plate. From the above characters it will be seen that the mandible is entirely *Hippopotamine* in character, and broadly distinguished from those of both *Sus* and *Anthracotherium*, in which the inferior border is nearly straight.

*Dentition.*—The dental formula most probably was the same as in *Sus* and *Hexaprotodon*; as much of the dentition as is known is given below, *viz.*:—

$$I\ \frac{?-?}{3-3}\qquad C\ \frac{1-1}{1-1}\qquad P\ \frac{4-1(?)}{4-4}\qquad M\ \frac{3-3}{3\ \ 3}$$

*Incisors.*—The incisors are at present unknown; from the shape and direction of their alveoli they must have been of comparatively small and equal size; they were in close opposition and probably projected obliquely from the jaw, their cutting edges forming a segment of an ellipse. There is no sign of any abnormal development in any of them, and they must therefore have approximated much more closely to *Sus* than to *Hippopotamus*.

*Canines.*—The canine is situated close behind and a little to the outer side of the third incisor; its inner border is in a line with the molar series; in both of the above respects it agrees with the canine of *Sus*, and differs from that of *Hippopotamus*. The cross-section of the canine is trihedral; two angles are placed in the antero-posterior line of the jaw, and the third on the inner side; these teeth are somewhat curved, the upper one more than the lower; they are not of larger size than the canines of the wild boar; the upper canine does not present the groove on its posterior surface which occurs in the corresponding tooth of *Hippopotamus*.

*Premolars.*—There is a considerable diastema between the canine and the premolar series; there is no jaw known* which contains the whole of the latter series *in situ*; the first premolar seems to have been implanted by a single fang, and was probably of very small size; the last three premolars were implanted by two fangs each. The hinder premolars are unsymmetrically conical teeth, of which the inner surface is flattened and nearly vertical; there are two grooves, and an intermediate ridge on this surface; the outer surface is rounded: there are semi-trenchant edges at the junction of these two surfaces, looking fore-and-aft: there is an accessory column at the antero-internal angle; the enamel is marked with irregular longitudinal striæ; there is a slight wavy cingulum surrounding the base of the crown. The premolars are strikingly like those of *Anthracotherium*.

*Upper molars.*—The upper molars are nearly square-crowned teeth, surmounted by four unsymmetrical cones (*specimens figured in "Fauna Antiqua Sivalensis" plate* 62, *fig.* 17, *and Owen's "Odontography," plate* 140, *fig.* 8). The cones are separated by a cruciform valley, of which the transverse division is by far the deeper; the general type, therefore, on which the tooth is formed is the same as that of the simpler teeth of *Sus*, *Tetraconodon*, and *Hippopotamus*. On the inner sides both inner and outer cones are perfectly symmetrical; the outer surfaces, however, of both pairs of cones are concave; these surfaces of the inner cones are simply concave, while the same surfaces of the outer cones have a median ridge running down the concavity, and a shorter lateral ridge at each of the outer angles of the cone. By this means a *Ruminant* form of the tooth has been engrafted on the original simple form; in *Ruminants* the transverse valley becomes almost obliterated by the approximation of the cones, and only remains as the groove separating the inner divisions of the cones (or barrels); on the outer side the transverse valley does not penetrate the crown, and its place is only marked by the division between the summits of the lobes; further, the antero-posterior valley becomes deeper between the cones (or barrels) and is divided into two portions by the united edges of the inner cones; the outer surfaces of the barrels, instead of being concave and sloping towards the inner side, as in *Merycopotamus*, become flat and vertical, retaining, however, the ridges found on the tooth of *Merycopotamus*.

The upper molars of *Merycopotamus* are surrounded by a distinct cingulum, less boldly marked on the outer surface than on the other three; and their enamel is rugose.

*Compared with Hyopotamus.*—The molar teeth of *Merycopotamus* are distinguished from those of *Hyopotamus* (another *Hippopotamoid* genus, showing *Ruminant* affinities in the form of its molar teeth) by those of the latter being less altered from the original *Tetraconodon* type; in the teeth of *Hyopotamus* the ridges which occur at the outer angles of the outer pair of cones of the molars of *Merycopotamus* are absent: in consequence, the outer border of the molars of the former genus forms a simple wavy line. There is also in the teeth of *Hyopotamus* the absence of the vertical ridge occupying the middle of the external surfaces of the outer cones which occurs in *Merycopotamus*. The inner cones, moreover, in the European genus are less concave on the outer side, and more regular in shape than in the Indian genus; while the former are further distinguished by the presence of a small additional cone in the re-entering angle on the anterior side of the first pair of cones. The molars of *Merycopotamus* are distinguished from those of *Dichodon* (with which Pictet compares them) by the completeness of the transverse valley in the former.

*Lower molars.*—The lower molars, like the upper, are intermediate between those of the *Pig* and *Ruminants*; they consist of four cones, of which the outer pair are the highest, separated by a cruciform-valley, of which the transverse portion is by far the deeper; the latter valley is shallower at the inner than at the outer side; the external surfaces of both inner and outer cones are nearly vertical; the inner surfaces of the outer pair of cones are concave; the posterior surface of the hinder one of the outer pair of cones is vertically grooved; an indistinct cingulum surrounds the base of the crown; there is no accessory tubercle at the outer extremity of the transverse valley; following the usual rule of the *Artiodactyla*, the third lower molar has three lobes, the hinder lobe consisting of a single cone, which corresponds to the outer cone of the middle pair.

The teeth are distinguished from those of *Sus* and its allies by the greater width of the transverse valley, and by its becoming shallower at its inner extremity, and by the longitudinal valley being broken up into two portions, which form the pits between the outer and inner cones.

The lower molars are distinguished from those of *Ruminants* by the transverse valley extending completely across the crown, instead of being confined to the outer side; whereas in *Ruminants.* the outer pair of cones are united nearly up to their summits, instead of only at their bases, as in *Merycopotamus;* further, the summits of the cones in *Ruminants* become wider, and the central infolds of enamel (the remnants of the primitive longitudinal valley) become deeper, and are connected together only by a narrow neck, which soon becomes obliterated by wear, causing the enamel pits to become complete islands, which remain until the tooth is worn down nearly to its base; islands only appear for a very short period on the crowns of the teeth of *Merycopotamus,* owing to the shallowness of the enamel folds. In the molars of animals like the *Giraffe* and *Brematherium,* where the enamel pits are connected together by a deep median fold, and consequently are a long period in becoming completely insulated, we have a remnant of a more generalized type of tooth, showing traces of the persistence of the primitive longitudinal valley of the Suine teeth.

*Measurements of skull.*—The following measurements are taken from the cranium, figured in the "*Fauna Antiqua Sivalensis*" (plate 67, fig. 1):—

| | In. |
|---|---|
| Length from occipital crest to superior angle of orbit | 6·0 |
| Width at superior border of orbits | 4·0 |
| Length of orbit | 1·9 |
| Width across zygomatic arches | 7·4 |
| Width at temporal fossæ | 3·7 |
| Length from foramen magnum to free border of palatines | 4·4 |
| Length from foramen magnum to last premolar | 8·1 |
| Width of palate at second molar | 1·9 |
| Length of three molars | 3·25 |
| Length of last molar | 1·24 |
| Width of ditto | 1·2 |
| Length of second molar | 1·0 |
| Interval between inferior border of foramen magnum and summit of occipital crest | 4·1 |
| Width of widest part of supra-occipital | 2·7 |
| Interval between external surfaces of occipital condyles | 2·85 |
| Vertical diameter of foramen magnum | 1·05 |
| Transverse ditto | 1·4 |
| Length of occipital condyle | 1·3 |

The dimensions of the skull of the adolescent animal from Burma (No 212) mentioned above, as given by Dr. Falconer ("*Pal. Mem.*" *vol.* 1, *p.* 148), are as follows:—

| | In. |
|---|---|
| Width of nasals at base | 1·9 |
| Extreme length of fragment | 7·5 |
| Greatest contraction of muzzle | 1·2 |
| Length of two (1 and 2) true molars | 1·9 |
| Ditto of two last premolars ... about | 1·3 |

The dimensions of the lower jaw figured in "*Fauna Antiqua Sivalensis*" (plate 67, fig. 4), are as follows:—

| | In. |
|---|---|
| Extreme length | 13·5 |
| Depth at middle of last molar | 2·45 |
| Ditto at second molar | 2·9 |
| Depth of descending angle below last of molars | 4·3 |
| Length from hinder extremity of last molar to canine | 7·9 |
| Length of symphysis | 4·4 |
| Interval between canine and symphysis | 1·4 |
| Thickness of inferior border below last premolar | 1·02 |
| Length of last molar | 1·6 |
| Width of ditto | 0·9 |

The dimensions of the hinder half of a right ramus of the mandible (No. 215) brought by Mr. W. T. Blanford from the Irrawadi valley are as follows:—

| | In. |
|---|---|
| Length of three molars ... ... ... ... ... ... ... | 3·25 |
| Length of last molar ... ... ... ... . ... | 1·6 |
| Width of ditto ... ... ... ... ... ... ... . | 0·8 |
| Length of second molar .. ... ... ... ... ... | 1·0 |
| Depth at middle of last molar ... ... ... .. .. | 1·8 |
| Ditto at second molar . . ... ... ... ... . . | 2·0 |

Other specimens from the Potwar country present similar dimensions to the above. These dimensions are smaller than those of the first specimen, the jaw being of a more slender type; the teeth, however, in the two are of the same size. Falconer conjectured that there were two varieties, major and minor. I think, however, it is more probable that the slighter jaws (and crania) belonged to female individuals and not to a distinct variety.

*Axis.*—The only portion of the vertebral column of *Merycopotamus* which I can identify is the axis vertebra, of which we have two specimens in the Indian Museum (Nos. 1638-39). These specimens only show the centrum, and portions of the pedicles, the neural arch being in both cases destroyed. The centrum has a broad and conical odontoid process laterally continuous with the articular facets for the atlas; the centrum is longer than broad; the inferior borders of the articular facets for the atlas form an almost continuous arch across the anterior extremity; there is a prominent straight keel along the inferior surface of the centrum; the inferior bar of the transverse process is long, and takes its origin about half-way up the vertebra; it is separated by a smooth space from the articular facet for the atlas, and is directed backwards and outwards; of the superior bar of the transverse process only the base is shown in our specimens; this is very wide and situated on the pedicle of the arch a little higher than the floor of the neural canal: the transverse process is perforated for the vertebral-artery. The exterior extremity of the pedicle is perforated for the upper branch of the spinal nerve. The posterior surface of the centrum is slightly hollow, wider than deep, with a horizontal upper border, and a curved inferior border.

The vertebra is at once distinguished from that of either the *Pig* or *Hippopotamus* by its much greater length in proportion to its breadth: in both the former animals the width of the posterior surface of the centrum is equal to two-thirds of the total length of the vertebra; whereas in *Merycopotamus* the width of the corresponding surface is less than half the total length of the vertebra.

*Comparisons.*—The axis vertebræ of the three genera have the following points in common: the transverse process is perforated by the vertebrarterial canal, and the pedicle by the foramen for the spinal nerve; the odontoid process is bluntly conical, the inferior surface of the centrum keeled, and the inferior bar of the transverse process is separated by a smooth surface from the articular facet for the atlas. The axis of *Merycopotamus* is distinguished from that of *Sus* (besides the difference of length) by the rim connecting the inferior borders of the facets for the atlas being less distinctly continuous below the odontoid process; by the odontoid process being wider and flatter; and by (in consequence of the greater length of the vertebra) the transverse process being much wider, and consequently the vertebrarterial canal much longer. It is distinguished from the axis of *Hippopotamus* by its greater proportionate length and the lesser development of the rim connecting the facets for the atlas; the transverse process is also slightly wider.

***Dimensions.***—The dimensions are compared below with those of the axis vertebra of the *Pig; Merycopotamus* in the first, and *Sus* in the second column:—

| | In. | In. |
|---|---|---|
| Length of centrum ... ... . .. .. | 2·8 | 1·7 |
| Width of posterior surface of centrum ... ... ... .. | 1·2 | 1·2 |
| Depth of ditto . .. ... .. .. ... | 0·9 | 0·8 |
| Width across anterior articular facets ... ... .. . | 2·2 | 2·[illegible] |
| Width of transverse process . ... . ... ... | 0·75 | 0·3 |
| Length of odontoid process ... ... ... . ... . | 0·6 | 0·6 |
| Width of ditto . . ... .. ... ... | 0·7 | 0·5 |

*Hinder limb.*—Of the hind limb, more or less complete portions of the following bones are known, either from the specimens in the British Museum (from which Falconer's figures are taken) or from specimens in the Indian Museum, *viz., Innominate, Femur, Tibia, Calcaneum, Astragalus, and Metatarsus.*

*Innominate.*—The innominate is known from the specimens of the acetabulum figured by Falconer ("*F. A. S.*," *pl.* 68, *figs.* 1 *and* 2), the acetabulum is completely circular and moderately deep, with a distinct pit for the attachment of the ligamentum teres; its diameter is 1·55 inches.

*Femur.*—At the proximal extremity the great trochanter is placed higher than in *Sus* and *Hippopotamus;* it is also more recurved, and the head is placed more nearly perpendicularly to the neck; it does not show any distinct impression for the ligamentum teres; the digital fossa is also deeper than in the allival genera. The distal extremity of the femur (*see Falconer's figures*) is very different from that of the *Pig* or *Hippopotamus*, and is unlike that of any living Ungulate; the trochlear surface for the paltella is unusually elongated, and its borders are placed almost parallel to the long axis of the bone, instead of very obliquely, as in other Ungulates: the condyles are consequently nearly equal-sized and symmetrical.

*Tibia.*—The proximal extremity alone of the tibia has been discovered: the articular surfaces are nearly equal sized and symmetrical: the prominence for the crucial ligaments is bifid; there is a notch and prominence on the anterior border as in *Sus*. in *Hippopotamus* this border is roughened, but not notched. On the posterior border in *Merycopotamus* there is a narrow notch, which is not found in the other genera

*Astragalus.*—Several views of the astragalus are given in plate 68 of the *Fauna Antiqua Sivalensis*, and we have several specimens of the bone in the Indian Museum, chiefly collected in Sind by Mr. Fedden; the specimen that I have measured is from the left side. The astragalus of *Merycopotamus* is formed on the same general plan as the corresponding bone of *Hippopotamus* and *Sus*, having distinct sub-equal facets for the articulation of the cuboid and navicular bones separated by an intervening ridge, which indicates the non-union of the two latter bones. Comparing the astragalus of *Merycopotamus*, firstly with that of *Hippopotamus*, we find that the former is distinguished by its greater length in proportion to its breadth, so that the breadth of the distal extremity is only equal to one-half the length of the bone, whereas in *Hippopotamus*, the corresponding breadth is equal to rather more than two-thirds of the length of the bone. In both bones the calcaneal half of the tibial trochlea is considerably the highest and stoutest of the two; the trochlear surface for the calcaneum is almost square in *Hippopotamus*, while it is oblong in *Merycopotamus*, and there is a deeper pit between this surface, and the commencement of the tibial trochlea. The articular surface for the cuboid in both is placed on a lower level than that for the navicular, while the latter extends further up on the posterior surface of the bone: both articular surfaces are of approximately equal width, and the ridge between the two is placed obliquely to the long axis of the bone. The lateral surfaces of the two bones have the same general characters. The astragalus of ***Merycopotamus*** is distinguished from that of ***Sus*** by its greater proportionate length, and by the articular surfaces for the navicular and cuboid being of nearly the same width, instead of that for the cuboid being only one-half the width of that for the navicular: further, the trochlear surfaces for the tibia are of nearly equal height in *Sus*. The great proportionate length of the astragalus of ***Merycopotamus*** is a character which it has in common with that of the *Artiodactyle Anoplotherium*. Below, the admeasurements of the astragali of *Hippopotamus sivalensis*, *Merycopotamus dissimilis*, and *Sus scrofa* are compared:—

| | *Hippo.* | *Meryco.* | *Sus.* |
|---|---|---|---|
| | In. | In. | In. |
| Extreme length ... ... ... ... | 3 9 | 2·25 | 1·75 |
| Width across tibial trochlear ... ... ... | 2·35 | 1·0 | 0·9 |
| Width across distal extremity ... ... ... | 2·35 | 1·25 | 1·0 |
| Width of cuboidal articular facet ... ... ... | 1·35 | 0·60 | 0 35 |
| Width of navicular articular facet ... ... ... | 1·5 | 0·66 | 0·65 |
| Length of calcaneal trochlea ... ... ... | 2·45 | 1·35 | 0·95 |
| Width of ditto ... ... ... ... | 1·95 | 0 75 | 0·65 |

The astragalus of *Anthracotherium* has the facets for the cuboid and navicular of unequal size, as in *Sus*, and is therefore at once distinguished from that of ***Merycopotamus***. Falconer once considered the two genera identical.

*Calcaneum.*—The calcaneum, as appears from Falconer's figures, appears to be of exactly the same form as the corresponding bone of *Hippopotamus*. It is distinguished from the calcaneum of *Sus* by its anterior surface being broader, and the whole shaft stouter, by the surface for the attachment of the tendo achilles being excavated in the antero-posterior line, instead of being convex, and by the facet for the articulation of the saddle-shaped trochlea of the astragalus being placed more obliquely. The length of the bone is 4·8 inches, and the width of the surface for the astragalus 2·3 inches.

*Metacarpal.*—The metacarpals are only known to me from the distal extremity of one of the middle bones brought by Mr. Fedden from Sind; the form of the fragment is essentially *Hippopotamine* and not *Suine*. The articular surface forms three-fourths of a cylinder; on the anterior surface there is no ridge on this cylinder, but on the posterior surface there is a marked ridge dividing the cylinder into two nearly equal portions: the shaft of the bone is nearly as thick as the cylinder. In the sub-equality of the portions of the cylinder on either side of the ridge, and in the limitation of the latter to the posterior surface, the bone agrees with the metacarpals of *Hippopotamus*. In ***Sus*** the ridge extends completely round the articular cylinder, and it is placed very much nearer to the median line of the foot, rendering the two articular surfaces very unequal. From the small extent of the ridge on the metacarpal of *Merycopotamus*, the first phalange of the digits has no distinct groove on its proximal surface: from the nearly median position of the ridge on the metacarpal, the foot must have been less symmetrical in relation to a line separating the third and fourth digits than in *Hippopotamus* and *Sus*; the general form of the metacarpal is very similar to the corresponding bone of *Anthracotherium*; width of distal extremity 0·65 inches.

*First phalange.*—Of the second phalange of the third or fourth digits we have several specimens in the Indian Museum: the bone is similar in shape to the corresponding bone of *Hippopotamus*, having the superior surface wide transversely, and hollowed, with prominent ridges on the fore-and-aft border; there is a very slight ridge running antero-posteriorly across the middle of the same surface. The anterior surface of the bone is rounded, and the posterior flat: the distal extremity presents a simple trochlea hollowed in the middle line, and extending further up on the posterior surface than on the anterior surface. Length 1·5 inches; transverse diameter of proximal surface 0·7 inch; antero-posterior diameter of proximal surface 0·6 inch; transverse diameter of distal surface 0·55 inch.

*Forearm.*—Of the forearm, we only know at present the humerus from its two extremities, the radius, and the distal extremity of the ulna; the two former bones are figured by Falconer.

*Humerus.*—At the proximal extremity we distinguish the humerus from that of *Hippopotamus* by the great tuberosity being less developed, which renders the bicipital groove less closed in by bone: the bicipital groove is unusually wide, and the deltoid ridge strongly marked; the posterior extension of the great tuberosity forms a more continuous rim round the outer border of the superior surface than in either *Hippopotamus* or *Sus.* The distal extremity agrees with *Hippopotamus*, and differs from *Sus* in the absence of the supra-trochlear foramen; the trochlear surface has the ridge on the radial half more prominent than in either of the allied genera; the ulnar condyle is more prominent than in *Hippopotamus.* Width of proximal extremity 3·5 inches; width of distal extremity 2·3 inches. The shape of the distal extremity is like that of the humerus of *Anthracotherium*, but the supra-trochlear fossa is deeper.

*Radius and ulna.*—The radius and ulna resemble those of the *Pig*, and differ from those of the *Hippopotamus* in being quite free throughout their entire length. The radius is a twisted bone with a triangular shaft; it is flatter than in the *Pig*, and is broader at the proximal and narrower at the distal extremity, so that the latter is the widest of the two surfaces; whereas the reverse is the case in the *Pig*: the bone is not contracted in the middle, as in *Hippopotamus.* The distal extremity of the ulna, on the other hand, is larger than in the *Pig*, and the bone takes a larger share in carrying the carpus: the larger size of this extremity of the ulna is a *Hippopotamine* character. The length of the radius is 7·3 inches, the width of the proximal extremity 1·7 inches, and of the distal extremity 1·05 inches. The greatest length of the distal articular surface of the ulna is 1·2 inches.

*Position of genus.*—From the above comparisons it will be seen that the osteology of *Merycopotamus*, as far as we know it, is very closely allied to that of *Hippopotamus* and *Sus*, but it presents certain characters different from that of both genera. Beyond a slight resemblance in the form of the teeth and of the astragalus, it does not show affinity to the *Anoplotheres*, among which it is placed by Pictet. I should be inclined to place the genus in the family *Hippopotamidæ*, forming a link between that and the *Anthracotheridæ*; the three genera *Merycopotamus*, *Hyopotamus* and *Anthracotherium* are aberrant forms, connecting the *Suine* to the *Anoplotheridæ* and the *Ruminantia.*

A curious mistake has been made regarding this genus by M.M. Pictet and de Blainville in the *Traité de Palæontologie* (vol. I, p. 322) of the former writer: a lower jaw described by Falconer (*Journal Asiatic Society, Bengal*, vol. VII, p. 1038), under the name of *Hippopotamus dissimilis* is placed under the genus *Hippopotamus*, with the remark—"Je pense que cette espèce est la même que celle qui est figurée dans le *Fauna Antiqua Sivalensis*, sous le nom de Tetraprotodon Pala-indicus."! In reality, the jaw should have been placed under the genus *Merycopotamus*, which is also described in the same work (p. 342); before the latter genus was determined, Falconer had referred all the bones belonging to it to *Hippopotamus dissimilis.* M. de Blainville has made a similar error to that of M. Pictet.

ADDENDA AND CORRIGENDA TO PAPER ON TERTIARY MAMMALIA (*ante page* 86) *by* R. LYDEKKER, B.A., *Geological Survey of India.*

HYDASPIDOTHERIUM MEGACEPHALUM, nov. gen. nobis.—The cranium from the Siwaliks referred to in the last number of the Records under the name of ***Bramatherium***, has now been cleaned from matrix, and turns out to belong to a new genus of ***Sivatheridæ***, for which I propose the name *Hydaspidotherium*, from the classical name of the river Jhelum, near which it was found. The distinctive characters of the cranium are the possession of one common horn-base on the vertex, and the absence of anterior horns; the profile is concave, the orbit depressed, and separated by a long interval from the horn-core; the teeth resemble those of *Bramatherium*. A figure and full description will subsequently appear.

The genus *Ursitaxus* (Hodgson's synonym for *Mellivora*) should be removed from the lists of extinct genera, p. 95, and added to the lists of genera common to the Indian Tertiaries, and to the living faunæ of India and Africa. The genus *Sanitherium*—H. von Meyer—(*Sus pusillus*, Falc.) should be added under *Artiodactyla* to the lists from which *Ursitaxus* is removed.

OCCURRENCE OF PLESIOSAURUS IN INDIA, *by* R. LYDEKKER, B.A., *Geological Survey of India.*

The discovery of the remains of this genus in the Oolite of Kachh is the first instance recorded of its occurrence in India. The specimen on which this determination is founded is a portion of the distal extremity of a mandible; it was discovered by Mr. Wynne at Burrooria in Kachh, in the Umia (Tithonian and Portlandian) beds; it comprises the whole of the symphysis and small portions of the rami of the mandible; on the right side it contains the alveoli of five teeth, and on the left side of four. The alveoli are completely surrounded by bone; the distal extremity of the symphysis is rounded, its upper surface flat, and pierced by neural foramina, interiorly to the teeth; there is an ovate prominence on the upper surface at the junction of the rami, the inferior surface is rounded and convex, the symphysis being rather longer here than on the upper surface. The dimensions of this specimen are as follows:—

| | In. |
|---|---|
| Length of symphysis on upper surface ... ... ... ... | 2·92 |
| Ditto ditto lower surface ... ... ... ... | 3·55 |
| Width of jaw at union of rami ... ... ... ... ... | 3·50 |
| Width of jaw at second alveoli ... ... ... . ... | 2·61 |
| Thickness of jaw at union of rami ... ... ... ... | 1·95 |

The specimen agrees almost exactly in form and size with the lower jaw of ***Plesiosaurus dolichodeirus*** of the English Lias; but it would not be prudent to affirm its identity till further specimens are discovered. The range of the genus in England is from the lower Lias to the lower Cretaceous, so that no inferences can be drawn from this specimen as to the homotaxis of the beds from which it is derived.

## NOTES ON THE GEOLOGY OF THE PIR PANJAL AND NEIGHBOURING DISTRICTS, BY R. LYDEKKER, B.A., *Geological Survey of India.*

The present paper is in continuation of Mr. Medlicott's paper on the Geology of the Jamú District (*supra*, p. 49); it treats of the inner band of the Sirmúr group,* and the rocks lying between them and the valley of Kashmír. The country lying in this area embraces part of the lower hills formed of the lower tertiary rocks, and the higher mountains composed of older rocks which divide Kashmír from the outer hills. Mr. Drew (*Jumoo and Kashmir Territories*, chaps. i and vi) has divided the mountain systems of the district into the regions of the "outer hills"; and of the "middle mountains;" divisions coinciding very frequently with the geological boundaries.

Notices of the geology of parts of this district have already appeared in various publications, the chief of which are—

Wynne, Records, Geological Survey of India.—Vol. VII, p. 64.
Verchere, J. A. S. B. Vols. XXXV—VI.
Godwin-Austen, G. J, G. S. L., Vol. XXII, p. 29, and Vol. XX, p. 383.

The physical features of that part of the district which is external to the division between the Sirmúr and older rocks are very similar to those which occur in Mr. Medlicott's country. Along the whole of the above boundary the general dip of the Sirmúr rocks is north-east or towards the older rocks—a feature prevalent for hundreds of miles along the Sub-Himalayas; and, except where anticlinals occur, the outer bands of the same rocks have also generally the same dip. The outcrops are usually abrupt and steep, presenting a very characteristic banded appearance: owing to the frequency of the north-east dip, the northern sides of the hills are usually those the most covered with vegetation.

In looking over the country from one of the higher inner passes, such as the Rattan Pír or the Hají Pír, the inliers of the "Great Limestone" of Mr. Medlicott are seen standing up as bold rugged cliffs, towering high above the rocks of the tertiary series, and easily distinguished from them by their "rocky" appearance.

It is, I think, a character very prevalent among the red rocks, that the higher ridges have generally a comparatively flat dip, while the rivers have excavated their valleys along lines where the dip approaches the vertical.

Along the inmost boundary of the Sirmúr group there is a sudden break between these rocks and the inner metamorphic series; the general dip of the former towards the latter group seems to show that this junction as it now exists is faulted. I have never seen any instance where I could distinctly assert that the red rocks had been deposited unconformably against the base of a cliff of metamorphics; and although I have not found any traces of the former overlying the latter beyond the fault, I cannot help thinking that such an extension must originally have been the case to a certain extent, and that the present relationship of the two has been brought about by subsequent up-or-down-thrusts.

In the extreme west of my district the red rocks are bounded by the confused limestones and shales of the nummulitic and oolitic series; owing to the heat of the season, I was not able to proceed up the Kishengunga valley to see the relations of these nummulitic lime-

* I use the term "Sirmúr" as convenient and unambiguous for the whole lower portion of the tertiary series, although it has not been geologically defined in the region under notice, as it is to east of the Ravi. The term "Marí" (Murree) has been more especially applied to the supra-nummulitic zone, the equivalent in the west of the Dugshai, or perhaps the Dugshai and portions of the east. This zone, with the upper part of the Subathú group, may also be sometimes indicated generally as "the red rocks."

stones to the metamorphic series; but I presume there must be continuation of the main fault between the two groups.

In certain places the lowest exposed beds of the metamorphic series consist of dark-blue limestone passing up into or alternating with shales; in other places the limestone series is not exposed; in the former case there is a great physical break in the country at the Sirmúr metamorphic junction, formed doubtless by the unequal disintegration of the limestone, and red clay and sandstone series; in the latter case the junction between the two formations does not form any marked feature in the country, the rapidity of weathering of the two kinds of rocks being approximately equal.

I do not think that there is any need of adding to the descriptions of the red-rocks given by Mr. Medlicott in his paper above quoted, their composition being exactly similar in my district.

In the lower part of the Marí district (Shaddita) the purple sandstones and red clays of the Sirmúr group rest suddenly upon the nummulitic limestone, without the intervention of the red and green splintery clays of the upper Subathú zone which occur to the eastward; it appears, therefore, that the bottom beds of the red series are unrepresented here: at Marí itself the splintery coloured clays are present, and the junction between the limestones and red series is transitional as in the original Subathú sections; but the great thickness of dark purple slatey shales which occur on the Píne River in the Jamú district (see Medlicott) do not seem to be fully represented here.

The whole of the nummulitic rocks forming parts of the high ranges to the west of Pindí and Marí appear to me from the general similarity of their mineral characters to belong to the Subathú series; and I do not see, in the absence of characteristic groups of fossils, any strong reason for separating these beds, under the name of Hill-Nummulitic Limestone, from the nummulitic limestones of the typical Subathú zone. It is true, however, that the upper limestone bands in the Marí district are frequently of a lighter colour than the lower, but, on the other hand, the shales in both the upper and lower beds are exactly similar in character to those of the typical Subathú zone of Mr. Medlicott: the whole of the nummulitic series in this district is undoubtedly of a much greater thickness than in Jamú; approaching thereby to the nummulitic series of Sindh (Blanford, Rec. Geol. Surv., Ind., *supra*, p. 8), and perhaps indicating a formation deposited in a deeper sea than that of Jamú. The exact or even approximate thickness of the nummulitics in this district, however, is very difficult to determine, since they are so mixed up with the very similar limestones and shales of the oolitic and underlying rocks, that it is almost impossible to divide the two.

In the nummulitics of this district there occur certain bands of thick-bedded dark limestone abounding in nummulitics which do not occur in the Jamú district; it is, I think, a by no means improbable suggestion that part of the purple clay series of the Jamú district (nummuliferous on the Píne River), and which I have said does not seem to be represented here, may really belong to the same horizon as part of the limestone and shale series in this district; the series in the Jamú district having been deposited in a more shallow sea than the present beds.

Mr. Wynne (*sup. cit.*) has described a number of purple sandstones and red clays intercalated between the upper and lower limestone series in the Marí district; these beds, or the greater part of them, are so exactly similar in mineralogical character to the overlying Marí beds, that I cannot but think their occurrence in their present position is due to faulting, though the relations of the different bands are difficult to determine, owing to crushing and talus deposits.

The course of the Jhelum between its bends at Mozaffarabad and Urí runs either on or near to the line of a broken anticlinal: the beds on the north bank are of a darker colour and more slaty structure with less sandstone, than those on the south bank, which are like the upper Marí beds; the beds on the north bank approach in character closely to those of the Píne River in Jamú. The Jhelum anticlinal continues its course near the boundary of the red rocks down to Púnch, where it becomes lost among the complicated disturbances and foldings which have there taken place.

From Urí to a little below Púnch it will be observed on the map that the strike of all the rocks becomes nearly due north and south, returning to its normal line at Rajaorí. The limestone hills to the east of the Hají-Pír are remarkable for their peculiarly even summits. A strong band of buff nummulitic limestone with black shale bands, capped by purple and green splintery shales, runs to the south from the Hají-Pír, dying out to the north-west of Púnch.

A well-marked anticlinal flexure runs through the purple rocks from Rajaorí to the north-west.

A north and south section along the course of the Ans River from Sar to Arnas cuts through the whole of the red series from the metamorphic junction to the Great Limestone at Riassi: the beds throughout this section have the prevailing north-east dip, and appear to be arranged in a series of step-faults; a fault seems to me to occur at the base of each main ridge, the lower beds always consisting of dark purple slatey shales with few sandstones, while the upper beds are composed of the brighter red clays and purple sandstones of the Marí series. I have never seen in any of these sections the coarse (Siwalik?) conglomerate capping the red series as described by Mr. Medlicott above Chineni.

Another large outcrop of the "Great Limestone" has been mapped by me along the north bank of the Chínáb, occurring as usual on a broken anticlinal line. At Shartalla this limestone is nearly vertical with a north-east underlie; it is succeeded suddenly by the red clays and purplish sandstones of the upper Marí series, with nearly the same dip and strike and apparently conformably; to the west of the village of Shartalla, however, the red beds of the spur on which the village stands are seen striking against the broken edges of a high cliff of the limestone, showing the existence of fault with a probably very great downthrow. No traces of the nummulitic series which occur in such force resting upon the Great Limestone at Arnas are seen at Shartalla.

Here I would say a few words as to the probable age of the Great Limestone, upon which, I think, the present inlier throws a little light. This limestone as it occurs at Riassi has been well described by Mr. Medlicott (*sup. cit.*); I may add that when seen from a short distance its general appearance is very massive, and exhibits but slight signs of distinct stratification in its lower beds, although Mr. Medlicott tells me the higher beds are more distinctly stratified.

The base of the limestone outcrop on the north of the Chínáb has precisely the same appearance as the Riassi limestone; but on passing north and coming to the topmost beds of the series at Shartalla, we find a great change in the character of the rock: instead of continuing with the same unstratified massive appearance, it becomes thin-bedded, less cherty in structure, and more blue in colour, with a very characteristic banded or ribboned look. These uppermost beds are exactly similar in character to the carboniferous limestone of Vernag in the Kashmír valley, described by Major Godwin-Austen (*sup. cit.*); and I think the two are very probably of the same age. The only fossil I found in the Shartalla limestone was a portion of a Fenestella, weathered out on the surface of a cliff, but which I was unable to detach; many portions of the Kashmír carboniferous are similarly unfossiliferous.

I will now proceed to describe the main features of the metamorphic rocks along the boundary of the Sirmúr group, taking sections across the strike at a few isolated points. Considerable difficulty must occur in dealing with these rocks, as they have hitherto proved unfossiliferous both to Major Godwin-Austen's and to my own search; I, moreover, have not seen any good instances of the super-position of newer rocks upon them from which an idea of their age could be gathered.

My first section is taken along the gorge of the Jhelum between the villages of U'rí and Báránúlá. The Sirmúr rocks at Urí have a high dip towards the metamorphics; the metamorphics also continue with the same dip within the fault.

Leaving the red rocks of the Sirmúr zone, the first beds we meet with consist of alternations of schists and limestones; the former are either red or green in colour and are frequently magnesian, and soapy to the touch; occasionally some of the green shale bands contain lenticular nodulars of chert; the limestone (some 150 feet in thickness) which at first alternates with, and then succeeds to, these shales, is dark blue in colour, soft and somewhat earthy, and never crystalline; it becomes gradually fissile, and seems eventually to pass up into the overlying slates, but the section is not very clear at this point. After very careful search, I could find no trace of any fossils in this limestone. Mr. Wynne, however, tells me that on the opposite (right) bank of the river he obtained a few very minute spiral Gasteropods. In mineral structure this limestone is totally unlike either the Nummulitic or the Great Limestone.

Both the limestone and its accompanying shales are but very slightly metamorphosed, while they are succeeded by highly metamorphic slates and quartzites, passing in some places into gneiss. It appears to me hardly likely that these underlying slightly-altered beds can really be older than the metamorphics; if this supposition be true, the outer series of the metamorphics must be inverted, which inversion, as I shall show below, must extend along the whole of the Pír Panjal and adjoining range. Mr. Wynne says that the U'rí limestone and shale series is very like in mineralogical character to the Triassic beds of Changla-galli and other places in the Hazara district, and is inclined to correlate the two. Dr. Stoliczka also conjectured that these beds were of Triassic age; on these grounds, these and similarly placed beds to the east have been conjecturally classed as Triassic in the map, though a strong objection to this view is noticed further on.

On leaving the limestone north of U'rí the flaggy slates continue with slight alterations in mineralogical character along the Jhelum valley into Kashmír; they are very thick and gritty at Urimybo, where they form almost inaccessible perpendicular cliffs along the left bank of the river. They become somewhat crystalline and hornblendic at Naoshera. There are several folds or faults in the section, but the dip is frequently concealed by metamorphic action. None of the so called amygdaloids occur in this section.

Along the river-bed there occur a great quantity of gneiss boulders, forming terraces above the present river level. Major Godwin-Austen supposes these to have been brought down to the present position by glacier action. The gneiss is not seen *in situ* anywhere along the road section, but occurs in the mountains on both sides. The gneiss is light grey in colour with large porphyritic crystals of white orthoclase.* The gneiss alternates with, and forms an integral part of, the metamorphic slate series, as will be more fully noticed in the Banihal section. Pebbles of the same gneiss are also found in the streams flowing from the Nilkanta Pass, showing that it extends as far west as that point.

* The Buddhist temple near Naoshera is built of this stone, and not of *amygdaloidal trap*, as stated by Dr. Bellew ("*Kashmir and Kashghar*," p. 53).

Mr. Mallet has kindly examined a specimen of this gneiss for me, and says that it is composed of the four following minerals, *viz.*, orthoclase forming the large crystals, frequently twins, of a dead white colour; milk-white quartz; and two species of mica, probably biotite and muscovite. This appears to be the same gneiss as that described by Dr. Stoliczka as containing albite veins.

The limestone band continues to underlie the metamorphic series from Urí to the Suran River, where I have taken another cross section; on the Bitarh River, between these two points, the green amygdaloidal rocks are intercalated with the slate series, a short distance from the limestone.

The section up the course of the Suran River towards the Pír Panjal Pass gives the following series of rocks. Leaving the red rocks of the Sirmúr group at the village of Draba, we come upon a thick band of dark-blue limestone (without polychroic shales) similar to that of Urí; the limestone is rather more altered and slaty than to the west, and is soon succeeded by thick-bedded flaggy shales, and then again by a variety of the peculiar amygdaloidal rocks noticed by Mr. Medlicott (*sup. cit.*, p. 52).

Before noticing these latter rocks, I must refer to a statement of Major Godwin-Austen, asserting the existence of nummulitic limestone on the southern face of the Pír Panjal (G. I., G. S. L., vol. XX, p. 385). The outcrop of limestone noticed above must, I presume, be the limestone referred to, as no other exists on the Pír Panjal. When Major Godwin-Austen speaks of the sandstone as overlying the limestone, he must imply a normal overlie with inversion, for the apparent relations from dip would place the sandstones of the Sirmúr group below the limestones; in reality the two are separated by a fault.

The passage of the limestone into the overlying slates, however, is so clear, that there can be no doubt but that they belong to this series. The only remaining question is—does the limestone contain nummulites? In answer to this, I can only say that after a very careful search I never met with any; and, moreover, Major Godwin-Austen himself makes no mention of having found nummulites in these beds; apparently, he only placed this limestone in the nummulitic group from its apparent association with the red rocks in the same manner as he at first supposed the limestone of the Dal Lake in Kashmír to be nummulitic, which afterwards turned out to be carboniferous. This limestone is serially continuous with that of Urí, in which both Mr. Wynne and myself have carefully hunted for nummulites without success.

Returning now to the so-called "amygdaloidal traps," we find these rocks of very common occurrence all along the Pír Panjal range. They were considered by Dr. Verchere to be of volcanic origin—a supposition which does not appear to me to be borne out by their mode of occurrence; unfortunately, I have mislaid the specimens which I had intended to bring down for examination.

These amygdaloids always occur interstratified with the slates of the metamorphic series, the passage between the one and the other being gradual. They generally also seem to be locally continuous in extent with the slate series,—not thinning out, as should be the case if they were contemporaneous traps; neither are there any beds of trap-ash in the series. There is no sign of any greater alteration in the slate beds which lie below them than in those above them, and the amygdaloids themselves are very distinctly stratified. The base of the rock is either green or purple in colour, and the amygdala either green or white, varying in size from that of a pea to that of a small walnut; they are frequently irregular in shape; the base is very hard and fine grained, and appears to be partly silicious.

In places, as on the Banihal Pass, these rocks pass imperceptibly up or down into almost unaltered earthy sandstones and grits, without amygdala; of these sandstones there can be no doubt as to their aqueous origin; in other places the amygdaloids pass up into slates. How far the former presence of cavities (now filled by amygdala) in these rocks militates against their metamorphic origin, as indicating the absence of excessive pressure, I leave to more experienced physicists than myself to judge; I have never seen these amygdaloidal rocks in contact with strata of the Sirmúr group, as noticed by Mr. Medlicott on the Raví (*sup. cit.*, p. 52). Whatever view may be held as to their origin, there can be no doubt but that they are contemporaneous with the great mass of rocks of the Pír Panjal. Dr. Stoliczka in his Yarkand Journal (p. 4) considers the similar amygdaloidal rocks of Kashmir as metamorphic.

Continuing our section up the Suran River, we come upon another band of blue earthy limestone at the village of Bifliage, followed by the same series of amygdaloids and slates. This second band of limestone appears to be faulted against the amygdaloids of the outer group, and is probably only a repetition of the same series. The whole of the rocks noticed above have a steady north-easterly dip. The green and purple amygdaloidal series come to an end about a mile below Baramgalla; they are succeeded by silky magnesian shales. Thick bands of white quartzite are here and there interstratified with the shales.

Owing to the great quantity of snow on the pass, I only went along the road as far as the halting place of Poshiana; shales and amygdaloids continue thus far with the same dip; pebbles of the same rocks form the only débris brought down by the streams, so these probably continue all the way up to the pass. The only other rock I noticed in the streams was a very hard silicious conglomerate, containing pebbles of quartzite and slate. I did not see this rock *in situ*; it probably indicates a break somewhere in the slate series. Gneiss does not occur anywhere on the south side of the pass. Between Baramgalla and Rajaorí the same slate and amygdaloid series continues, but the Urí limestone is not exposed at the base.

To the eastward of the Pír Panjal Pass, along the valley of the Aus River, I have not been able to take any section across the strike of the strata for a considerable distance, having merely followed the boundary of the metamorphic rocks. The series of rocks in this region exposed at the base of the slate series differ considerably in character from those to the westward. At the village of Kiol the following series is well exposed along the bank of a tributary stream; the section is from below upwards:—

*a.*—Purple or white, fine grained, glistening quartzites; base not exposed, and top only seen at intervals.

*b.*—Black shales (50 to 200 feet thick), containing thin bright bends of brittle coal, and nodules of iron-ore; in many places the shales are altered into hard black slates.

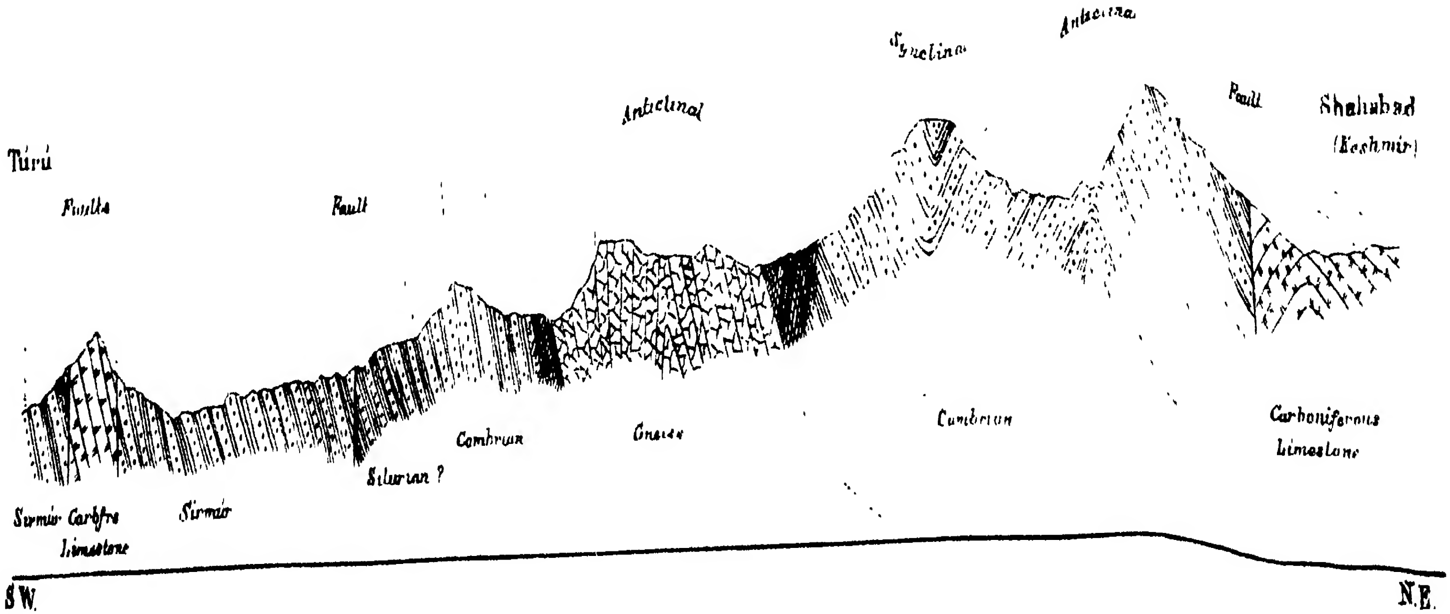
*c.*—Dark blue earthy limestone, frequently bituminiferous; sometimes massive but more usually nodular, passing gradually up into the next zone.

*d.*—Amygdaloidal and black slate series.

These I shall subsequently designate as the Kiol group.

The limestones appear to be very similar in mineralogical character to those of Urí, occupying the same relative position under the metamorphic series. The coal shales are not found at Urí, but occupy the position of the green and purple shales of that place. The coal never occurs in layers of more than an inch in thickness, and these do not extend continuously for more than short distances. The occurrence of these slightly altered limestones and coal shales at the base of the metamorphic series, seems to point to the same conclusion as at Urí, *viz.*, inversion, these strata being the newer of the two.

At the village of Sang on the Aus River, the white quartzites of the Kiol series are seen abutting by a faulted junction against the red sandstones and clays of the Sirmúr




Sketch Section of the Pir Panjál at Banihal.

group, the contrast of the two colours forming a very striking feature, seen for many miles down the valley. The coal-bearing shales of the Kiol group become more altered towards the east; up the valley of the Golabgarh stream porphyritic gneiss similar to that of Urí occurs; the gneiss alternates with the slate series.

The Kiol series corresponds somewhat in mineralogical characters to the Math and Kuling series of Dr. Stoliczka (*Notes on North-Western Himalaya*, Mem. Geol. Surv. Ind., vol. V, p. 135), both alike containing white quartzites, shales, limestones, (altered) sandstones; the Kuling series is, however, of Triassic age, and from their position and from the absence of carboniferous limestone beneath them, I doubt whether the Kiol series could belong to the former period; they seem rather to correspond with the lower beds of Major Godwin-Austen's sections to the north of Pír Panjal, which Dr. Stoliczka conjectured might be of Silurian age. The great mass of metamorphic rocks on the north side of the Pír Panjal may still be considered as of Cambrian age, the Kiol series as probably Silurian, and perhaps partly carboniferous, while the Great Limestone of Mr. Medlicott should be entirely carboniferous. The limestones and shales of Urí correspond in relative position with those of the Kiol series, and may very probably be placed on the same horizon. Mr. Wynne thought the Urí rocks were of Triassic age; but then, as in the case of the Kiol series, there would be no representative of the great carboniferous limestone between the Urí limestones and the metamorphics.

The accompanying diagrammatic section taken from the village of Turu on the east bank of the Aus River into Kashmír, explains my idea of the sequence of the strata. The ridge of central gneiss forms an unsymmetrical anticlinal axis, covered by inverted Cambrian strata on the south, and followed by Cambrian and Silurian strata, much contorted and folded, on the north; beyond the Silurians there is a fault separating them from the carboniferous limestones of Kashmír.

The last section which I have taken extends from the Chínáb River, across the Banihal Pass into Kashmír, and is partly represented in the foregoing diagram. The bright red clays of the Sirmúr series are nearly vertical where they lie against the metamorphics on the Chanz River. Along the north bank of this river the limestones and shales of the Kiol series are not exposed. The rocks seen consist of black and rusty brown slates, generally splitting into irregular flaggy masses, intercalated with frequent beds of quartzite. At the distance of about a mile and a half up the Bichlari stream, we come upon a fine-grained gneiss, sometimes hornblendic and sometimes porphyritic like that of Urí, this gneiss has at first a north-easterly dip of about 60° (inverted), becomes quite vertical at Pantol, and beyond this again requires a north-easterly underlie. The vertical rocks of Pantol form lofty cliffs between which the river flows in a narrow gorge. At both its boundaries the gneiss intercalates with semi-crystalline rocks, and these again with the slate series, so that it becomes almost impossible to define on the map the exact boundaries of the different rocks.

The gneiss does not extend to the northward beyond the village of Gangna, at which place it is succeeded by the overlying series of black and green splinting schists. In places there are a few bends of the green amygdaloids; and a few veins of carbonaceous shale occur in the shaly grits which occur about three miles north of Gangna. A little above Goond there are a few bands of blue earthy limestone, alternating with coarse greyish sandstones and grits, showing but very slight signs of metamorphism. Along the Banihal stream a synclinal and an anticlinal fold run through the grit strata.

On the Banihal Pass these strata contain bands of white and pinkish cherty grits, black flaggy shales, and a few green amygdaloids, all with a steady north-easterly dip; there are also a few bands of a fine-grained grit conglomerate and strings of white quartzite. These rocks, as being the uppermost of the metamorphic series, correspond well in position and character with the Bhebeh or Lower Silurian series of Dr. Stoliczka, who suggested (*Notes on Western Himalaya*, p. 350) that part of the metamorphic rocks on this line belonged to the Silurian series.

On the north side of the Banihal Pass there appears (as shown in the section) to be a faulted junction between the metamorphic and the carboniferous limestones of Kashmír (Godwin-Austen, *sup. cit.*); the limestone at the junction dips towards the pass at a high angle in the opposite direction to the dip of the metamorphics.

The gneiss ridge has nearly the same strike as the gneiss of the Dhaoladar range, and the Kiol limestone has the same relative position in regard to the Banihal gniess as the Krol limestone of Mr. Medlicott has to the Dhaoladar gneiss (Medlicott, Mem.) Geol. Surv. Ind., vol. III, map and sect., p. 63); and it is quite possible that the two series are contemporaneous. Dr. Stoliczka has, however, attempted to correlate the Krol limestone with his Kuling (Triassic) series; according to my view, however, the Urí Kiol and Krol limestones are more likely to belong to the Bhabeh or Silurian series, forming an interrupted zone along the base of the Dhaoladar and Pír Panjal ranges for a long distance.

On the low pass at Baramúlá, there occur large masses of modern strata of sand, clay, and very coarse gravel. These beds rise to a height of at least 500 feet above the present level of the river, and are tilted at an angle of about 9° to the eastward; many of the pebbles are crushed *in situ*. These beds are quite different in structure from the Kareewahs of the Kashmír valley, and differ also from the latter in being tilted. As none of the superficial alluvium in the outer hills have been disturbed from their original horizontal position, it is, I think, probable that these Baramúlá beds are older, possibly Siwalik.

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| Fragments of a meteorite which fell at Judesegeri village, Tumkoor district, Mysore, on the evening of the 16th February 1876 ... ... | Chief Commissioner, Mysore. |
| Fragments of a meteorite ... ... ... | Sent by the Agra Archæological Society to Asiatic Society, Bengal, and transferred to the Indian Museum. |

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*4th October 1876.*

RECORDS

OF THE

# GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1877. [February.

## Annual Report of the Geological Survey of India and of the Geological Museum, Calcutta, for the year 1876.

*Gondwana formation.*—The past year has certainly been one of special advance in our knowledge of Indian formations; we have at last successfully grappled with our great plant-bearing series of rocks, now known as the Gondwana system—the only extensive fossiliferous formation of peninsular India. This advance is, of course, due to palæontological aid. The splendid work on the cretaceous fauna of Southern India, produced by Dr. Stoliczka in the Palæontologia Indica, after several years' labour, will no doubt, for a long time to come, be a standard of reference in the examination of rocks of that age, besides its independent merits as a study of a great branch of natural history. The same may be said of the work on the Jurassic Cephalopoda of Kach by Dr. Waagen, noticed in the last annual report. Yet it is not too much to say that the results of a few months' study by Dr. Feistmantel have been of more immediate service to the Survey.

The explanation of this is simple. Both the treatises referred to deal with rocks that only occur in patches on the outskirts of the peninsula, whereas the Gondwana deposits occupy large areas; and, on account of their economic importance, they have been from the beginning the chief object of our investigations. It would seem as if there were here a case of misdirected labour; but it must be recollected that, on the whole, marine creatures form an immense proportion of fossil remains; and, as a consequence, comparatively few palæontologists are capable of dealing with a fossil flora. I am happy to say we are now well provided in this way.

As an illustration of these results, I may mention the case of a large spread of rocks marked down by Mr. Hughes in the Pranhita valley. Two localities of this area have for many years been famous as having yielded remarkable vertebrate fossils, from which, and from the general aspect of the deposits, it had been considered that these beds were on the horizon of the Panchets, in the lower Gondwana series of Bengal. This year a few poor plant-fossils were found with the bone beds of Kota and Maleri. From these, and in their order of superposition, Dr. Feistmantel at once detected representatives of two groups of upper Gondwana deposits, the Jabalpur and Rajmahal, established by him from the study of the floras of the typical areas.

This case affords also an example of independant verification, which is always such a welcome encouragement, as a confirmation of the soundness of our methods. Where the Gondwana rocks tail down towards the sea, on the border of the Godavari delta, they become associated with marine beds. Mr. King has been for some time working in this region, and has established three well-marked groups in upper Gondwana rocks,—a bottom one, with a well characterized Rajmahal flora, and two upper ones, with distinctive marine fossils. From a cursory inspection of these latter specimens, Dr. Stoliczka had recognized the upper group as corresponding with his Umia group, at the top of the jurassic series of Kach, with the flora of which group Dr. Feistmantel has identified that of the Jabalpur group of the Narbada and Sone regions. During the past season, Mr. King was directed to make a traverse up the Godavari, to bring his work into connection with Mr. Hughes' ground on the Wardha and Pranhita. He has satisfactorily recognised in the Kota-Maleri area representatives of his three upper Gondwana zones of the Lower Godavari.

While thus the internal economy of the Gondwana system is being regulated in a most satisfactory manner, I fear that its foreign relations are being somewhat mismanaged. They are now quite a burning question amongst us. Palæontologists come from their cabinets in Europe with the fixed idea that the "laws" they have seen to work so neatly as between Bohemia and Bavaria, or from Durham to Dorsetshire, will apply equally well between India and Australia, or Europe; and the eager aim of their labours seems to be to tally off our Indian rock-groups as the representatives, or equivalents, of certain fossiliferous series of Europe or elsewhere. From the beginning, this palæontological fallacy has been a chief obstruction to our knowledge. When first the Gondwana fossils were taken up, pure geology being in the ascendant, the fact that certain plant-forms of the lower Gondwana rocks were somehow associated with beds having a carboniferous marine fauna in Australia, was made the basis of a special-pleading to show that the Damudas, their flora, and their coal were palæozoic. The materials have now come into the hands of a pure palæontologist. He has shown, I believe conclusively, that the Gondwana flora is wholly mesozoic, nailing its several phases to certain representative zones in Europe. But it so happens that on the confines of India, east and west, the upper Gondwana groups are associated with beds having a marine fauna, according to which these said groups have already been attached by palæontological experts to other standard groups in Europe. It is true that the study of this fauna was only partial; but the experts were very accomplished in their line, and their judgment was quite unprejudiced, so that it must carry great weight. Here then, again, is an opening for the procrustean method of research; and there are symptoms that it is to be duly applied; this time, to make the fauna conform to the flora. The expression 'palæontological contradiction,' which has been applied to this fact of association, exhibits the predicament in a very naïve manner. The contradiction is certainly there, but only as a rebuke for those who can look upon it in that light. No theologian could be more impious in reducing the mysteries of existence to the compass of his narrow thoughts, than are often scientific specialists in imposing crude conceptions upon the proceedings of nature. Yet these ought to know better—that truth is discovered, not invented.

The treatment the facts of our Gondwana system have thus received in the name of homotaxis is quite opposed to scientific principles. It is fiction to assume that palæozoic and mesozoic faunas have not co-existed upon the earth. The very word *homotaxis* was introduced to meet facts of this order. Yet, when some approach to it is met with in the rocks, a lively dispute is set up as to which fauna is out of place! The dispute becomes doubly awkward when waged over a terrestrial flora *versus* a marine fauna. A compromise that the marine fauna should take precedence would be a miserable confession of weakness, and quite out of place in a rational investigation. It would only tend to crystallize that false notion of misplacement; to frustrate, in fact, that fruitful conception of a purely biological homotaxis which should be as a pole-star to the palæontologist. The vicious practices of giving different specific names to fossils for no other reason than that they occur on different stratigraphical horizons, even at distant localities, and of trimming species to suit a fancied age, are the offspring of these false assumptions. Such a practice must utterly confound the attempt to work-out the natural history of organic evolution.

The facts of our Gondwana rocks are certainly puzzling to systematists: on the west, in Kach (Cutch) we have the flora of the top Gondwana group, which has a Bathonian facies, associated with marine fossils of Tithonian affinities; while on the south-east, in Trichinopoli, beds with a flora (so far as known) like that of the Rajmahal group, which is taken to be liassic, have been described by Mr. H. F. Blanford* as overlaid, in very close relation, by the Ootatoor group, the fauna of which has been declared, upon very full evidence, to have a Cenomanien facies.

These questions of homotaxis concern the whole body of naturalists as much as they do us; and I hope some guiding spirits amongst them will keep a watch on our proceedings. Happily these foreign relations do not interfere with the local regulation of our rock-systems. The terrestrial fauna and flora of the Gondwanas is developing into a compact unity of its own, and its relations to contiguous marine fossil faunas is normal, so far as this word can be legitimately used.

Omitting the original account of the Narbada or Satpura field, in which the succession of the rocks was altogether misunderstood, the Survey has hitherto been engaged almost entirely upon outliers of the Gondwana system, where the series is more or less broken. This order has been imposed upon us by geographical and economical conditions. The great central areas of South Riwah and the Satpuras have still to be worked in detail. The latter seems to present a very full series in unbroken succession. It is here that we may expect ultimately to establish a better knowledge of this important formation.

The work of Messrs. King and Hughes on these rocks has been noticed above. Mr. Foote was also engaged on the same formations, in examining the chain of outliers of upper Gondwana deposits along the coast of the Carnatic. He sent in a fine series of fossils from these beds at Vamavaram.

It had been arranged that Mr. Ball should make an exploration of the large area of unknown country between the Mahanadi and the Godavari; but he was detained to investigate the re-discovery of the Talchir coal-field by the Civil Officers of Orissa. In connection with this duty, he was able to complete the mapping of the Raigarh and Hingir coal-basin, which is on the south-east extension of the great Gondwana area of South Riwah and Sirguja. A narrow strip of Talchir beds stretches from that basin to within two miles of the Talchir field. He also examined the sedimentary basin west of Cuttack, on the margin of the Mahanadi delta, and procured some plant-fossils from the Atgarh sandstone, which Dr. Feistmantel recognises as of the Rajmahal flora.

*Tertiary formations.*—An important gap in our knowledge of the Sub-Himalayan tertiaries has been filled up by the past season's field-work. MM. Medlicott, Theobald and Lydekker made an outline-survey of the broad band of tertiary deposits flanking the Pir Panjal, in the Jamu territory, thus connecting previous work in the Cis-Ravi and Trans-Jhelam regions. The discrepancy that existed in the sections of these two regions has been, in a manner, interpreted—by the greater, and thereby earlier, elevation in the direction of the Central Himalaya, whereby the apparently unbroken succession of deposits, from the nummulitic to the upper Siwaliks, as exhibited on the Jhelam, becomes gradually separated into bands that are at least locally unconformable. The extreme effect of this is exhibited in the oldest beds: the inner belt of nummulitic and associated deposits

* Memoirs, Geological Survey, Vol IV, page 47.

is in great force all through the Jamu hills; at the Ravi it becomes contracted; at the Sutlej it is upraised on a base of the older formations of the higher mountains; before reaching the Jamna, it has been completely and permanently removed by denudation. East of the Jamna there only remain the outer zones, composed of Siwalik rocks.

The complete change of strike that occurs so abruptly along the valley of the Jhelam has been shown to be quite a continuous feature, not connected with any marked difference in the age of the contrasting systems of disturbance.

Our chief disappointment in this ground was not being able to determine satisfactorily the age of the great inliers of old limestone that in several places obtrudes through the inner zone of tertiary rocks in Jamu. From some obscure indications of fossils, they have been coloured on the sketch-map as carboniferous; but this is quite an open question. The triassic age of the fringe of limestone along the base of the Pir Panjal is also more or less conjectural.

This trip afforded an opportunity of testing the speculations published in our Records for 1874 by Mr. Theobald, on ancient glaciers in the Kangra district. The conclusion was come to that the so-called moraines are only the remains of a diluvial deposit that had once deeply covered the valley.* At the same time it is difficult to account for the characters of this deposit without the supposition of active glacial conditions on the Dhaoladhar range. The coincidence is not to be lost sight of that these high-level gravels along the Himalayan border, locally with glacial characters, are, according to physical methods of computation, of an early pleistocene age, more or less corresponding to that of the glacial period of Europe.

In connection with the tertiary rocks we can also claim for the past year a special advance in our knowledge, and again through palæontological aid. Since the labours of Cautley and Falconer, the fossil vertebrates have been the subject of most wide-spread interest in Indian geology. We have at last been able to make a beginning in carrying on that line of research. I trust that Mr. Lydekker's papers in our publications for 1876 will fully support this promise. A general result, so far, seems to be that the Siwalik fauna is of pliocene rather than of miocene affinities; but we have still made very little way in marking stages in this great tertiary fauna. This difficulty is, of course, one of field-geology, and it is very great. There is an enormous succession of conformable deposits, with much uniformity of character throughout, and fossils are very rare except in one broad zone having an upper middle position in the series. The whole formation, moreover, has undergone extreme disturbance.

The conjectured identification of the topmost Siwalik beds with the ossiferous deposits of the Narbada valley is one of great interest, on account of the discovery in these of a well-formed stone implement, as described in the Records for 1873.

In the far east, in upper Assam, Mr. Mallet completed his survey of the coal-fields of the Naga hills. For the extent and quality of the coal this is certainly the most important of our Indian coal-fields, and yet it is entirely of tertiary age, possibly even middle tertiary. On account of the total change in the character of the associated rocks, the relation of these measures to the nummulitic coal of the Khasia hills could not be established without a continuous survey of the intervening ground; but the intimate connection of the Assam measures with overlying deposits of Siwalik type, suggests that they may be on a higher horizon.

* Records, Vol. IX, page 56, 1876.

On the south-west extension of the Sub-Himalayan series Mr. Blanford, assisted by Mr. Fedden, accomplished a good season's work on the tertiary deposits in Sind. A preliminary sketch of these formations, from the previous season's field-work, was published by Mr. Blanford in the Records for 1876 (p. 8). The most important addition made to the geology of Sind since the date of that report consists in the discovery of cretaceous rocks (a Hippurite limestone) at the base of a group of beds underlying the Ranikot or infra-nummulitic group. Several very important facts concerning this group have also been ascertained; its upper limits and the division between it and the overlying Kirthar group have been better defined, and very large additions have been made to the fossils obtained from it. Mr. Fedden during the recess season in Calcutta has made a very useful preliminary classification of these collections in the Museum. It has further been definitely ascertained that the basalt of Ranikot is interstratified with the sandstones and shales of the Ranikot group; and a bed of basaltic rock, apparently the same, has been traced at intervals to Jakhmari, a distance of over 20 miles. This basalt is on the horizon assigned for the Deccan trap.

*Older rocks.*—Early in 1876 Mr. Blanford made an important trip across the desert east of the Indus, through Umarkot and Balmir to Jodhpur, and back through Jesalmir to Rohri. We have thus gained most interesting information regarding a great area of western Rajpootana that has hitherto been almost unknown. The journey did not quite extend to the gneissic and slate rocks forming the centre of the Arvali region. The oldest formation observed on the inner zone consisted of peculiar porphyroid rocks; a prevailing type being a dark compact silicious felsite with disseminated felspar crystals and quartz, associated with syenitic and granitoid varieties. They are locally much disturbed. Mr. Blanford supposes these Maláni beds to be altered volcanic rocks.* He does not liken them to any he has seen elsewhere in India; but it may be worth recalling that peculiar felsitic beds have been described in the Kadapah and Gwalior formations, and even in the Lower Vindhyans of the Sone valley.

Upon these rocks, in the neighbourhood of Jodhpur, there rest quite unaltered and very little disturbed a considerable thickness of rusty sandstones, at the base of which Mr. Blanford doubtfully places a very peculiar contiguous deposit of fine shales with large boulders, which suggest the action of ice, the supporting rock having, moreover, exhibited in one place a smoothed and scored surface. A Vindhyan horizon is suggested for these deposits, and the specimens are certainly most of that type; otherwise one might risk the conjecture that they may be lower Gondwanas, and that the boulder-bed represents that of the Talchirs.

The relation of the Jodhpur sandstones to the next formation on the west has not been defined, the two not having been observed in proximity; but the unconformity must be total, as the succeeding deposits, within a small distance, also rest upon the Maláni felsitic series. They consist of brown and white sandstones in which silicified wood and other plant remains are frequent. The fossils of these Balmir beds are not identifiable, but the rocks have a strong Gondwana aspect, and may safely be reckoned as such, being closely related to the overlying marine jurassic rocks of Jesalmir, consisting of alternating sandstones and limestones.

The marine jurassics of Jesalmir are transgressively overlaid on the west by a nummulitic limestone, identical with that of the Kirthar group, as seen at Rohri on the Indus. All the infra-nummulitic and cretaceous beds of the trans-Indus section are thus totally over-

* I notice a contemporaneous description of very similar rocks of palæozoic age in Australia as altered volcanic products. See Mr. Brough Smith's Report of Progress of the Geological Survey of Victoria, No. III, p. 199, 1876.

lapped. For a full account of these important observations I may refer to Mr. Blanford's paper in the current number of the Records.

The observations just noted have supplied a knowledge of the western margin of a well-defined but little explored geological region—that of which the Arvali hills (or mountains) form the best-known geographical feature, stretching to the south-south-west into Guzerat, and passing on the north north-east under the Indo-Gangetic plains, about their water-shed, and touching the Jamna at Delhi. The eastern limits of the region are very well marked by the scarp at the Vindhyans, stretching from near Agra to Chittorgarh and Neemuch, and thence by the scarp of the Malwa plateau formed of the Deccan trap. The Arvali region is believed to be formed entirely of gneissic and transition rocks, the remains of an exceedingly ancient mountain system, or area of special disturbance; even the Vindhyan formation exhibits little disturbance within its confines. For some seasons past Mr. Hacket has been engaged upon these rocks in the north. Last year he carried his lines as far as Jaipur. The isolated condition of the outcrops, in detached ridges and hills separated by wide plains of sand or of alluvium, makes it very difficult to discover the normal order of succession of the several groups of rocks, all being without a trace of fossil remains. Our difficulty here at present is the occurrence, within a moderately large area, of several strong rock-groups, having much mutual resemblance, and each independently in natural contact with a fundamental gneiss.

Mr. Willson was also engaged upon the older rocks, having completed the mapping of the Bijawar formation in Bundelkund, with a large adjoining area of overlying lower and upper Vindhyans, and of the underlying gneiss.

Mr. Wynne did not return from furlough till the end of the field season. He has since done important work in the Museum in arranging the Kach and Salt Range collections.

For the first time since the institution of the Survey the annual report has to record the retirement upon pension of any of the staff. Dr. Oldham resigned the post of Superintendent in April, after a tenure of 25 years. The work done up to date will form a permanent record of the value of his services. Mr. Tween retired in September, after a service of 15 years, for the greater part of which time he had zealously performed the duties of Chemist to the Survey. In both cases, failing health made the step unavoidable. The loss we have thus sustained is the more felt, since it is determined that, for the present at least, the number of our staff cannot be restored to its full strength.

*Publications.*—Of the MEMOIRS of the GEOLOGICAL SURVEY of INDIA, Volume XII was issued during the past year. Part 1 is the result of several seasons' work by Mr. R. Bruce Foote, and includes a very large area in the South Mahratta Country, where several basins of our azoic formations occur between the great spread of the Deccan trap on the north and the gneiss forming the whole middle area of the peninsula to the south. The small skeleton-map attached to the Memoir does very poor justice to the accuracy and detail of Mr. Foote's work, the whole of which is ready for publication on the Indian Atlas sheets, as soon as a plan can be matured for the regular issue of our work in that form. Part 2 is Mr. Mallet's report on the coal-fields of Upper Assam. It will be a very useful guide in the practical exploration of that field.

Volume XIII was fully passed for press before the close of the year. Part 1, containing Mr. Hughes' memoir and maps of the Wardha valley coal-fields, will be issued before the date of this report. Part 2 is Mr. Ball's memoir on the Rajmahal Hills, with numerous maps and illustrations, the preparation of which has caused some delay.

I am happy to be able to announce that good progress has been made in the preparation of a Manual of the Geology of India. The map was sent in for colour-printing in July last, but it is a very heavy piece of work. Several of the plates of fossils are already printed, and I hope the work may be ready for issue about the middle of the current year.

The RECORDS for 1876 contain many papers giving abstracts of current work, or discussing important questions relating to it.

Of the PALÆONTOLOGIA INDICA the Jurassic Flora of Kach, with 12 plates, was issued in December. A similar treatise on the Flora of the Rajmahal Hills is nearly ready for issue. The publication of these figures and descriptions of the plant-remains of the Gondwana system will be of immense service in working out those formations, large areas of which still remain to be examined.

A fasciculus by Mr. Lydekker, with seven plates, on some tertiary vertebrate remains will be issued before the date of this report. Of all the work we have in hand none will be received with so much interest as information regarding tertiary and post-tertiary mammalia.

I have the pleasure to record that a first class medal was awarded for the exhibits of the Geological Survey of India at the Congrès International des Sciences Géographiques, held at Paris in 1875.

*Library.*—The Library of the Geological Survey has received an addition of 992 volumes or parts of volumes during the year 1876.

Of this number 536 were purchased and 456 were received from Societies and other Institutions in exchange for the publications of the Survey, or as donations.

Quarterly lists of these additions are published in the Records, and a nominal list of Societies and Institutions from which presentations or exchanges have been received is appended.

*Museum.*—Much has been done during the past year in getting the new museum into order. The mineralogical gallery is now fairly provided with cases, and the systematic arrangement of the collections has made good progress. Mr. Mallet's catalogue of the minerals will, I hope, be ready for publication this year. In the palæontological galleries no new case-room has been as yet provided, so that large parts of the collections are unavailable for show or for study. The cases we have are being used for the Indian specimens. The several series of the general collections have for the present to be packed away. The specimens of the Asiatic Society's collections have been amalgamated with those of the Geological Survey in the Indian Museum.

CALCUTTA,
*February* 1877.

H. B. MEDLICOTT,
*Supdt. of Geological Survey of India.*

*List of Societies and other Institutions from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1876.*

AMSTERDAM.—Royal Society of Batavia.
BELFAST.—Natural History and Philosophical Society.
BERLIN.—German Geological Society.
„ Royal Prussian Academy of Sciences.
BOMBAY.—Bombay Branch of Royal Asiatic Society.
BOSTON.—Museum of Comparative Zoology.
„ Boston Society of Natural History.
„ American Academy of Arts and Sciences.
BRESLAU.—Silesian Society of Natural History.
BRISTOL.—Naturalists' Society of Bristol.
BRUSSELS.—Royal Academy of Sciences.
BUFFALO.—Buffalo Society of Natural Sciences.
BUDAPEST.—Royal Geological Institute of Hungary.
CALCUTTA.—Asiatic Society of Bengal.
„ Agricultural and Horticultural Society.
COPENHAGEN.—Royal Danish Academy.
DRESDEN.—The Isis Society.
„ The Leopoldino Carolina Academy of Naturalists.
„ The Royal Museum.
DUBLIN.—The Royal Dublin Society.
„ Royal Geological Society of Ireland.
EDINBURGH.—Royal Scottish Society of Arts.
„ Royal Society of Edinburgh.
GENEVA.—Physical and Natural History Society of Geneva.
GLASGOW.—Philosophical Society of Glasgow.
„ Glasgow University.
GÖTTINGEN.—Royal Society of Science.
JEFFERSON CITY.—Geological Survey of Missouri.
KÖNIGSBURG.—Royal Society.
LAUSANNE.—Vaudois Society of Natural Science.
LIVERPOOL.—Literary and Philosophical Society of Liverpool.
„ Geological Society of Liverpool.
LONDON.—Royal Geographical Society.
„ Royal Society.
„ Geological Society of London.
„ Royal Asiatic Society of Great Britain and Ireland.
„ British Museum.
„ Linnæan Society.
MANCHESTER.—Geological Society.
MELBOURNE.—Geological Survey of Victoria.
„ Mining Department, Victoria.
„ Royal Society of Victoria.
MONTREAL.—Geological Survey of Canada.
MOSCOW.—Imperial Society of Naturalists.
MUNICH.—Bavarian Academy of Sciences.
NEUCHATEL.—Society of Natural Science.
NEW HAVEN.—The Editors of the American Journal of Science.

NEW ZEALAND.—Geological Survey of New Zealand.
,, New Zealand Institute.
PALERMO.—The Royal Institute.
PARIS.—Mining Department.
,, Geological Society of France.
,, Anthropological Society.
PHILADELPHIA.—American Philosopical Society.
,, Academy of Natural Sciences.
,, Franklin Institute.
PLYMOUTH.—Devonshire Association.
,, Geological Society of Cornwall.
PISA.—Natural History Society of Tuscany.
ROME.—Geological Commission of Italy.
ROORKEE.—Thomason College of Civil Engineering.
SALEM., MASS., U. S. A.—American Association for the advancement of Science.
,, Essex Institute.
,, Peabody Academy.
STOCKHOLM.—Bureau Géologique de la Suède.
,, Royal Academy.
SYDNEY.—Philosophical Society of New South Wales.
,, Royal Society of New South Wales.
TORONTO.—Canadian Institute.
TURIN.—Royal Academy of Science.
VIENNA.—Imperial Academy of Sciences.
,, Imperial Geological Institute.
WASHINGTON.—Smithsonian Institute.
,, United States Geological Survey.
,, Dept. of Agriculture, U. S., A.
YOKOHAMA.—German Naturalists' Society.
YORK.—Yorkshire Philosophical Society.
ZÜRICH.—Swiss Natural History Society.

Governments of India, Madras, Bombay, North-Western Provinces and the Punjab; Chief Commissioners of British Burmah, Central Provinces and Mysore; Surveyor-General of India, Superintendent of the Great Trigonometrical Survey of India, and the Meteorological Reporter to Government.

## GEOLOGICAL NOTES ON THE GREAT INDIAN DESERT BETWEEN SIND AND RÁJPÚTÁNA.

BY W. T. BLANFORD, A.R.S.M., F.R.S., &c., *Geological Survey of India.*

### I.—INTRODUCTION.

The following notes were made during two traverses of the great desert region east of the Indus,—the first from Sehwan on the Indus through Umarkot, in the Thar and Parkar division of Sind, to Jodhpúr, *viâ* Bálmír, the second further north and in the reverse direction, from Jodhpúr to Rohrí on the Indus, *viâ* Jesalmír. The length of the first traverse was above 350 miles; of the second about 300.

The only previous geological notices of any part of this tract with which I am acquainted consist of a few remarks by Dr. Carter in his "Summary of the Geology of India between the Ganges, the Indus, and Cape Comorin,"* principally relating to the occurrence of granitic rocks near Bálmír, and of some further details procured by the same author from Dr. Impey† concerning the rocks seen on a journey from Rohrí to Jodhpúr *viâ* Jesalmír, Dr. Impey's most important observations being the occurrence of ammonites at Kuchrí and of fossil wood at Láthí. The ammonites were referred by Dr. Carter to *A. opis*, Sow., a Jurassic species found in Cutch (Kachh).

The physical geography of the region has been frequently described; the latest and best description with which I am acquainted being by Sir H. B. E. Frere‡. On this subject I have already published some notes recently§.

### II.—DESCRIPTION OF ROUTE FROM UMARKOT TO JODHPÚR.

*Sandhills and lakes east of the Eastern Nárra.*—From the Indus near Sehwan to the Eastern Nárra, the route lay over the alluvium of the Indus Valley. The Eastern Nárra is an ancient river channel by which the Indus probably, at one time, poured its waters into the western portion of the Ran of Cutch. Immediately to the east of the Nárra a change takes place, nearly the whole surface of the country being composed of sandhills running in parallel lines with a general north-east—south-west direction. Between the sandhills are long stretches of water, many of them extending for as much as 15 or 20 miles, of considerable depth, supplied from the Nárra. Farther to the eastward, amongst the sandhills, are isolated pools of water, all of them salt; the saltest, which are a saturated solution of brine, being farthest east and containing, besides common salt, sulphate of lime in sufficient quantity for crystals of gypsum to be formed. These salt-ponds are at a lower level than the long lakes near the Nárra, and apparently derive their water from the latter by percolation, for water always runs in at their western extremities, and the salt must be derived from the soil. It is evident that the original surface of the country can have been no higher than the bottom of the lakes, which is at a depth of many feet below the channel of the Nárra, itself beneath the general level of the Indus alluvium. It is also manifest that the soil beneath the sandhills is strongly impregnated with salt. Both these circumstances are in favour of this tract of country having been an arm of the sea in recent times, and this probability is confirmed by the existence in some of the brackish water lakes of a mollusk, *Potamides* (*Pirenella*) *Layardi*, H. Ad., which inhabits salt-lagoons on the coast, and must in all probability have found its way to these now isolated pools of water when they were in communication with the sea.

* Jour., Bombay Br. R. A. S., Vol. V, and Geological I

† Jour., Bombay Br. R. A. S., Vol. VI, p. 161.

‡ Jour., Roy., Geog. Soc., 1870, Vol. XL, p. 181.

§ Jour. A. S. B., 1876, XLV, Pt. 2, p. 86.

*Umarkot to Bálmír.*—From Umarkot to Godra (60 miles) the road is over sandhills, with the same general strike north-east—south-west; but towards Godra the hills decrease in number, and sandy plains intervene. For about 35 miles from Umarkot, all well-water is very brackish, the wells being in sandy clay; farther to the eastward, although no rock is seen at the surface, sandstone is found at a little depth, and sweet water is procured. The edge of the sandstone may mark the limit of the old estuary, and hence the brackishness of the water to the westward.

Sandstone is also seen in some tanks near Godra. It is fine, whitish or pinkish in colour, rather felspathic, soft and often nodular from containing concretions of carbonate of lime. From a well in Godra, besides the sandstone, pinkish clay, a gritty ferruginous rock resembling laterite, and compact gritty limestone have been procured. No fossils were found, and it is difficult to ascertain what the beds can be. They may be either Jurassic or Tertiary, the former being perhaps rather more probable.

Near Rámsir, 15 miles east of Godra, hills of hard rock begin to appear, at first isolated and of small extent, but farther to the eastward forming ranges of considerable height. These hills are chiefly composed of a very hard felsite-porphyry, dark-coloured and closely resembling jasper in texture. In some places, as at Redano hill, and again at Jessai, coarsely crystalline granitoid syenite and pegmatite are associated with the felsite. These felsites and their associates may be called for convenience Maláni beds.*

These rocks continue as far as Bálmír, and extend for a considerable distance north and south of the road. The town of Bálmír is built partly at the base, partly on the slope of a hill, which, like several others to the northward, consists of sandstones, resting upon the dark-coloured felsites. At the base of the formation is a coarse conglomerate of felsite pebbles; above this are whitish and grey sandstones, sometimes very compact and hard, but elsewhere softer and veined or blotched with purple. A few ill-marked plant remains occur in these rocks.

These beds dip at 20° to 25° to the north-east on Bálmír hill, a small outlier occurring on the top of the highest hill, a trigonometrical station. The same rocks continue for a mile, or rather more, along the edge of the hills to the northward, and re-appear in some isolated hills in the sandy plain north-north-west of Bálmír, the farthest observed being five or six miles from the town. Some of the sandstones are used for building, and are well adapted for the purpose.

North and east of Bálmír is a great sandy plain with occasional sandhills. At a village called Kapúlí, 12 miles to the north, a very fine unctuous clay resembling fuller's earth is found and quarried to some extent. It is associated with hard buff shale and some calcareous grit. The beds roll about at angles of 15° to 20° and may belong to the same group as the Bálmír sandstones. A calcareous conglomerate is exposed about the village of Mohábar, 3 miles south-south-east of Bálmír, and fragments of similar rock are seen north of the town, about the tanks. This conglomerate contains pebbles both of the Maláni felsites and of the Bálmír sandstone and is probably of late origin.

*Bálmír to Jodhpúr.*—At Sáokar, eight miles east of Bálmír, much calcareous tufa occurs, apparently deposited from springs. The water at the village is very hard, evidently containing lime, and so brackish as to be unfit for drinking. No solid rock is seen in place for 30 miles east of Bálmír, on the road to Jasol, with the exception of this calcareous tufa.

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* Maláni is the name of the district of which Bálmír is the chief town. It belongs to Jodhpúr but is at present under British management.

The sandhills increase in number to the eastward; they are not arranged in long north-east—south-west ridges as near Umarkot, but in more irregularly formed rises, always steeply scarped to the north-east, and often shewing evidence of considerable denudation from rain.

Three miles before reaching Náosir, some sandstone is seen, precisely like that of Bálmír, but dipping at low angles. The same rock forms hills to the south near Sárun and Sanpha. The first-named ridge extends for some miles, the beds dipping about south-40°-east, towards an exposure of diorite, which is probably a member of the Maláni beds. Porphyritic felsite is seen on both sides of the Sanpha hill, to the east and to the west. The relations of these different outcrops is not very clear; but for the occurrence of felsite west of Sanpha hill, it might be supposed that the broad tract from Bálmír to Náosir is occupied by the Jurassic rocks of which the Bálmír sandstones, as will hereafter be shewn, are the base, but the ground requires further examination.

At Náosir a variety of felsite occurs which is very quartzose and of a reddish colour, almost resembling red quartzite in places. The usual dark-coloured porphyry with red felspar crystals is exposed at the Lúni river and forms the range of hills south of Jasol. The large hills to the south-east in the direction of Jallor are probably of the same rock, which may extend as far as the Arvali range.

North of the Lúni river near Jasol, a somewhat depressed plain, in the neighbourhood of the town of Pánchbhadra, has long been the seat of an extensive manufacture of salt, The tract is much covered with sand, but is lower than the surrounding country, and may be the site of an ancient salt lake, or of a tract of low country covered at one time by the sea, if an inlet extended up the Lúni valley. The salt is obtained from pits into which brine trickles, and is evaporated by the heat of the sun.

For many miles below Jasol no rock is seen in the bed of the Lúni river, and there is a flat alluvial plain south of the river, which here runs east and west. At Jasol some coarse conglomerate, found on the bank of the stream and used for building, is apparently a sub-recent formation. From Jasol to Jodhpúr, a distance of 60 miles, the whole country appears to be alluvial; no rock is met with, except in a few isolated hills, all of which consist of the Maláni felsites.

These felsite-porphyries and their associates, here varying more than usual in character, and comprising beds which unmistakably resemble volcanic ash, are well developed at Jodhpúr, and the greater portion of the town itself is built upon them. The commonest variety is a brownish-red porphyry with the usual red felspar crystals, the ash beds being well seen about three miles south-west of the town.

*Jodhpúr sandstones.*—The long ranges of low flat-topped hills, however, which extend for many miles south-west, west, and north of Jodhpúr, consist of red sandstone, which may perhaps be of Vindhyan age. It is certainly quite distinct from the sandstones of Bálmír, and appears to be older. It is, as a rule, rather coarse, often obliquely laminated, and it frequently contains small pebbles. It is largely used as a building stone; some kinds bear carving, and its resistance to the destructive effects of exposure is amply proved by various old buildings in the neighbourhood of Jodhpúr.

The Maláni felsites only occupy the town itself and a patch of ground extending three or four miles to the south-west and north-east, the sandstones resting upon them to the north-west, and a sandstone outlier forming the fort of Jodhpúr itself. The sandstones are quite unconformable to the felsites. To the east and south-east of the town is a broad sandy alluvial plain. In this plain between one and two miles east-north-east of the fort, shale, pale-greenish and dark-red in colour, is found in wells. The relations of this shale are obscure; it may belong to the sandstone group.

### III.—Route from Jodhpūr to Rohri via Pokran.

*Jodhpúr to Pokran.*—On the road leaving Jodhpúr in a west-north-west direction red sandstones are seen at intervals as far as Lowo, a distance of 80 miles. Two small exposures of Maláni beds were observed near Jodhpúr, one near the village of Palrí, eight miles north of the town, the other in a stream-bed, 4 miles farther north, near Managrá. The sandstones are well seen to beyond Tiyúrí, 20 miles north-west of Jodhpúr, rising into low hills: and similar rises extend nearly twice as far in a direction a little north of west; but from Tiyúrí to Lowo rocks are only seen at rare intervals, the country consisting of sandhills with broad sandy flats intervening between them. The sandhills continue for about 40 miles, and then gradually becomes lower, less extensive, and more distant from each other, until they finally disappear between Dechú and Mandlo. They have no definite arrangement in ridges, but present, as usual, steep scarps to the north-east.

It is impossible to say whether the Jodhpúr sandstones continue throughout the area beneath the sand. They appear here and there, and the only other rock seen was some shale of a greenish colour which is exposed in a tank just west of Dechú, 60 miles from Jodhpúr, and may belong to some beds better seen at Lowo. Beyond Mandlo the country is very flat, and some portions, which appear to be depressed below the general level, form salt plains. Three of these are passed between Mandlo and Pokran, one at Daidia, a second north of Lowo, and the third, which is by far the largest, a few miles east of Pokran. The origin of these plains is very obscure: they may have originated in changes of level, though there is a possibility of their being portions of old valleys dammed up by sand. When rain falls, water accumulates in them to a small extent, and, evaporating, leaves a thin crust of salt. Similar salt plains were seen near Redano hill, west of Bálmír. The amount of denudation from rain in this region must be singularly small, or such shallow depressions would be filled up.

The red Jodhpúr sandstone is seen east and west of the Daidia plain, and it forms a continuous low scarp to the north of the plains at Lowo and Pokran. But at Lowo itself some peculiar gritty and sandy shales are seen, mostly hard and sometimes porcellanic, of various shades of red and green, and containing in places pebbles and boulders of all sizes up to many feet in diameter, composed of felstone porphyry and granitoid syenite, all apparently derived from the Maláni beds. These shales stretch across towards Pokran, where they occur to the south and west of the town. About half way from Lowo to Pokran there is a considerable outburst of basalt, the relations of which are not clear, no similar rock having been found associated with the volcanic Maláni beds.

The town of Pokran appears to be built upon sandstone, but the rock is badly seen, and is cut up by veins of calcareous tufa. To the north the same rock forms a low escarpment; whilst south, west, and south-east of the town volcanic rocks occur, clearly belonging to the Maláni porphyries, and consisting of felsite of various colours, often pale-green or slate-coloured, with, in places, grains of transparent quartz and the characteristic felspar crystals. In many places these rocks have a distinctly stratified appearance, due probably to imperfect cleavage.

Upon the volcanic rocks rests, in places, a thick deposit of boulders derived from them, in a matrix of coarse red grit. Green shales, precisely like those of Lowo, are associated with this boulder bed, which contains rounded fragments of all sizes up to two feet in diameter. At one spot, a short mile south-west-by-west of Pokran, where the surface of the porphyry, underlying the boulder-bed, was exposed, it was unusually smooth and distinctly striated, the *striæ running north-east—south-west. This is strongly confirmative of the probability of glacial action having contributed to the transport of the large boulders seen at Lowo. It should, however, be mentioned that the boulders seen near Pokran were all rounded,* and none exceeded the dimensions often carried down by an ordinary stream.

About a mile north-west of Pokran, in some ravines, the sandstones are seen abutting against both Maláni beds and shales, and apparently resting unconformably upon both.

*Pokran to Jesalmír.*—From Pokran to Láthí, the country is a sandy plain in which rock appears at but few places, and is even then very ill seen. The few exposures which occur belong to various groups, and it is often difficult to assign them with any certainty. Four miles west of Pokran, volcanic rocks (Maláni beds) are exposed in a tank, and a few fragments seen on the road-side further west are probably the same. About nine or ten miles from Pokran, red sandstone is seen in place; but it is conglomeratic, and does not resemble the Jodhpúr beds. Near Odhania some old-looking impure limestone occurs, of various colours, yellow, brown, slatey, white, &c., associated with whitish quartzite. Some of the limestone resembles that of the Lower Vindhyans.

At Odhania itself grey shaley sandstones are seen in a tank east of the village, whilst to the north-west massive greyish and white sandstone and grit are exposed, and quartz pebbles scattered over the surface indicate the presence of conglomerate. These beds differ from anything previously seen and probably belong to the Jurassic series. West and south-west of Odhania fragments of diorite and porphyry occur, containing, besides felspar, hornblend or augite crystals; and, about half a mile west of the village, fine grained syenite is seen in place. These rocks evidently belong to the Maláni series.

On a rise two miles west-20°-north of Odhania, scattered fragments of white quartzite are seen; then, half a mile farther west, a conglomerate is exposed of various pebbles, chiefly felsite, in a matrix of red grit. This bed precisely resembles the boulder-bed of Pokran. Half a mile farther quartzite recurs; it is finely laminated and white or grey in colour. This was the last exposure of the older beds noticed. The quartzites and old limestones may belong to the same series as the shales and boulder-beds of Lowo and Pokran, but nothing can be determined from the very poor exposures seen.

About four miles before reaching Láthí, dark-brown, hard ferruginous sandstone is seen, resembling the "iron bands" of the Máhádéva and Kámthi beds, and the same reappears a mile further on a rise to the north of the road. This rock belongs to the lower portion of the Jurassic beds. For a mile or two before reaching Láthí, and for about the same distance west of the village, soft whitish and reddish sandstones are exposed in a hollow, which has been the bed of a stream. The beds are nearly horizontal; they abound in fragmentary vegetable remains, none of which, however, can be identified. Large blocks of silicified wood occur unrolled; none of the larger fragments were seen in place, but smaller pieces, less well preserved, are embedded in the sandstone.

For many miles west of Láthí there is the same sandy plain as to the eastward rocks being only seen at very few places, as at Sodakhor, six miles west of Láthí, where calcareous conglomerate with sandstone pebbles, grey sandstone, and black ferruginous sandstone occur; nothing more is seen for twelve miles. Near Sháwal a low scarp is crossed, consisting of the same grey sandstone, with hard blackish ferruginous bands; and this scarp can be traced for a long distance to the southward. A little farther west yellowish-brown limestone crops out, weathering red and containing fossils, apparently *Gasteropoda*. The succession of low scarps dipping westward shews that an ascending series of beds is traversed, the westwardly dip being, however, very low.

*Neighbourhood of Jesalmír.*—Three or four miles north-west of Hanúra, a higher scarp of buff-coloured limestone is reached; it rests upon sandstone, and this scarp extends to Jesalmír. Above the scarp the ground is rocky, and a second scarp of very similar limestone and sandstone exists at a short distance from the first. Some of the sandstone is very hard and vitreous. The beds have a low dip to the northward, and six or eight miles farther in that direction another scarp of rocks, higher in the series, is seen.

Jesalmír is at the base of the lower scarp, the fort being built upon a detached outlier. The same scarp extends for some distance to the west, then turns south-west. It can be traced about six miles from the town, the beds throughout being the same buff compact sandstone, resting on whiter calcareous beds, and these again on grey sandstones with occasional ferruginous bands. Six miles from Jesalmír, near a stream-bed called Kákana, the rocks begin to roll about, but they are said to be traced some six miles farther, to a village called Mohar, before being covered up by the sand of the Thar. The surface of the limestone above the scarp is very distinctly striated by the action of sand driven by the wind, the striæ running about north-35°-east. The limestone abounds in marine fossils of Jurassic age.

The limestone is an admirable building stone, and is largely quarried. Jesalmír is built of it; and slabs are exported all over the country for temples, tombstones, &c., some having been taken even as far as Sind. It is used for fine carving, some of the pieces which have been taken to Sind having elaborate Arabic inscriptions cut upon them; it is of uniform texture and very fine grain, and it resists the action of the weather well.

The rocks south and south-east of Jesalmír are much better exposed than to the eastward, and are seen in descending sequence as far as Kíta, a distance of about fifteen mlies, all having a low dip, usually less than 1°, and never exceeding 2°, to the north-west. From Kíta to Vinjorai all the country is said to be covered with sandhills. At Vinjorai it is said that peaked hills occur; these may consist of the Maláni porphyries. The beds seen between Jesalmír and Kíta are doubtless identical with those between Jesalmír and Láthí: for the first ten miles they consist of a succession of limestone beds interstratified with sandstones. Just south-west of the fort at Jesalmír there is a low scarp of impure brown limestone resting on soft grey sandstone. Below this again, south-by-east of the fort, and south of a large tank, some hard grey limestone is found, abounding in small shells; it is quarried to a small extent for ornamental purposes. It contains fragments of buff limestone and pale-yellow calcareous shale. Beneath these beds occurs a succession of brown limestones, brown and grey sandstones, often calcareous, ferruginous sandstones, dark-brown or blackish in colour, and conglomerate, containing pebbles of quartzite, red jasper, and ferruginous sandstone, the last precisely like that found in the beds beneath all the limestones. Other conglomerates contain fragments of grey sandstone and ill preserved fossil wood, mixed with ferruginous nodules, in a yellowish calcareous matrix.

The lowest band of limestone forms a well-marked scarp, which is seen extending for many miles to the south-west. Beneath it soft grey sandstones, with hard brown or black ferruginous beds, prevail, all dipping slightly to the north-west. At Kíta soft, white and variegated sandstones occur, the former in every respect resembling the beds of Láthí, and, like them, containing in abundance indistinct vegetable fragments. In places these fine, white, rather micaceous beds are stained with lilac, purple and scarlet in irregular veins and blotches, and they then are much like some of the Bálmír sandstones, except in being softer. It is not seen on what these rocks rest. To the south-east, in which direction lower beds might be found, all the country is covered with sand-hills.

*Jesalmír to Rohrí.*—The country to the north of Jesalmír was not examined. Limestone is said to extend in this direction for about fifteen miles. Westward, on the road to Rohrí, the Jesalmír limestone bed is traversed for seven or eight miles, then after two miles of sandy plain, some low hills are crossed, consisting of calcareous sandstone, partly whitish, partly dark-coloured, with a little limestone. These beds appear to overlie the Jesalmír limestone. The next rocks seen form a low ridge north-west of Chitrail, about fourteen miles from Jesalmír, and consist of blackish ferruginous sandstone, dark-brown calcareous sandstone, whitish calcareous sandstone—which weathers into heaps of fantastic forms, resembling bones or stems of trees—yellow and buff sandstones, and white sands, streaked and variegated with purple. These beds have a low north-west dip, less than 1° in general, and consequently they appear to overlie the beds of Jesalmír. Very little rock is seen for ten or twelve miles to the westward, the little which is seen being similar to that near Chitrail.

A mile west of Kuchrí, twelve miles from Chitrail, another low scarp appears, consisting of dark calcareous sandstone resting upon soft, white sandstone. On the top of the scarp there is a band of buff and brownish limestone, sometimes changing to red where exposed, and abounding in *Ammonites* of three or four kinds: an *Arca* and other bivalves also occurring, and there is a bed of oysters. It was a fragment of this rock, brought by Dr. Impey, which was examined by Dr. Carter, and recognized as of Jurassic age.

These beds have a low dip to west-north-west. In the valley to the westward, some soft grey sandstone of the usual Jurassic character is seen, with, as usual, hard ferruginous beds interstratified. West of this again, four or five miles from Kuchrí, is a steep scarp of Nummulitic limestone, resting on the Jurassic beds. The junction is clearly unconformable, although the unconformity is not marked and the bedding of the two formations is nearly parallel. On the top of the scarp is a bed of the rock characteristic of the Khirthar limestone weathering with a rugged nodular rubbly surface, and containing *Nummulites Ramondi*, *N. Leymeriei?* and *N. Beaumonti*. Below this are softer yellowish beds, and near the base are some greenish and buff shales, associated with an impure limestone containing *N. Spira*. This band, doubtless, represents the lowest bed in the Rohrí hills, in which *N. Spira* is especially abundant. No trace of the green clays seen below the limestone of the Rohrí hills, or of any of the infra-Nummulitic and cretaceous beds of Sind, could be recognized.

The scarp extends for many miles to the north-east; to the south-west it is covered by sand-hills. Westward the limestone extends for about two miles beyond Kuyálá, or between four and five miles altogether, and patches occur beyond; at first at short intervals; but after three or four miles, no more are met with until one is seen amongst the sand-hills about seventeen miles from Kuyálá, and another halfway between Asú and Gotarú. About five miles west of Kuyálá, near some wells called Bánda, there is an inlier of buff limestones and ferruginous sandstone, evidently belonging to the Jurassic rocks, surrounded by nummulitic limestone.

On the road which passes through Asú, sand-hills begin to cover the ground completely about six or seven miles before reaching that village, which is twenty-two miles from Kuyálá, and they continue thence for the greater part of the distance to Rohrí. Near Asú and Gotarú, they are arranged in long ridges, having a general direction of about north-20°-east to south-20°-west; but towards Mitráhú, the first place where fresh water occurs within the Sind frontier, the regular ridges cease and irregular hills occur, often scarped steeply to the north-north-east. Alluvial tracts and marshes appear between the hills, and the country is within the limits of the Indus alluvium.

## IV.—Summary of Geological Observations.

*Formations observed.*—From the preceding account of the journey, it will be seen that in the tract traversed the following formations were distinctly identified:—

| | | |
|---|---|---|
| 9. | Blown sand ... ... ... ... | Post tertiary. |
| 8. | Alluvial deposits ... ... .. ... | |
| 7. | Nummulitic limestone ... ... ... | Tertiary. |
| 6. | Ammonitiferous beds of Kuchrí ... ... | Jurassic. |
| 5. | Jesalmír limestones and sandstones ... ... | |
| 4. | Bálmír sandstones ... ... ... ... | |
| 3. | Jodhpúr sandstones... ... ... ... | ? Vindhyan. |
| 2. | Shales and boulder bed of Lowo and Pokran ... | ? |
| 1. | Maláni felsite, porphyries, syenite, &c. ... ... | ? |

*Maláni beds.*—It is evident that these, the oldest rocks met with in the portion of the desert traversed, are volcanic. Their extremely silicious nature may be due to alteration but their porphyritic character, and the occasional occurrence of ash beds, sufficiently attest their volcanic origin. They consist principally of very silicious felsites, so hard that they are not scratched by quartz, and have frequently the appearance and texture of jasper. They vary greatly in colour, from black or dark-drown to pink, blue or white, the dark-coloured rock being always hard and undecomposed, whilst the lighter-coloured varieties are softer and appear to be altered. The most constant character is the presence of small crystals of felspar, usually of a pink or red colour, in addition to which small grains of transparent silica are frequently dissiminated throughout the rock.

In places diorite was found associated with these rocks, and in some of the hills west of Bálmír, coarsely crystalline granitoid syenite and pegmatite are intercalated in large masses with the porphyritic felsites. True granite may occur, but in the few hills examined mica was absent, although the character of the rock was distinctly granitic. The presence of similar granitoid rocks elsewhere is rendered probable by the occurrence of pebbles and boulders in some of the later beds.

The Maláni rocks must be very ancient, but no idea can be formed of their geological position, as they are nowhere associated with rocks of known age except where underlying beds of comparatively recent date, and nothing resembling them appears hitherto to have been detected elsewhere in India. They form the hills extending upwards of 30 miles west of Bálmír, and south as far as Chotan, 25 miles south-west of Bálmír, and north probably to Vinjorai, 35 miles south-south-east of Jesalmír. South of the Bálmír hills, no rocks are known to occur for a considerable distance, but the syenite hills of Nagar Párkar, which are in this direction, may probably belong to the Maláni series. To the eastward of Bálmír no rocks are seen for 30 miles, but the porphyritic felsites are extensively developed on the Lúni river for many miles below Jasol and Pánchbhadra; they appear to form a portion at least of the high hills south-west of Jasol, towards Jallor, they constitute the few rocky hills which rise out of the sandy plain between Pánchbhadra and Jodhpúr, and they reappear at Jodhpúr itself, where some of the beds are unmistakable volcanic ash. On the road from Jodhpúr to Jesalmír, their presence, except near Jodhpúr, was only detected in the neighbourhood of Pokran.

2. *Shales of Lowo and Pokran.*—The next series of beds in ascending order consists of peculiar green, red, and variously coloured shales, occasionally soft, but often hard and even porcellanic. Some are fine, others are coarse and sandy, and contain grains of pink felspar, and of a green mineral resembling epidote; some beds being composed throughout of one or the other of these minerals. In places, pebbles and boulders of the Maláni porphyries and syenite are found towards the base of these shales; the boulders being occasionally

from three to four feet in diameter, whilst remains of much larger blocks, which had fallen to pieces, but which could not have measured less originally than twelve to fifteen feet in diameter, were seen about Lowo. These boulders appear to have been brought from a distance, and there is some reason for supposing that they may have been transported by ice, as the underlying surface of the Maláni porphyries near Pokran was in one instance found to be grooved and striated.

These beds also can be identified with no known Indian formation. The shales were found around Lowo and Pokran, and some quartzites, limestones, &c., of ancient appearance, but which are very ill seen in places west of Pokran, may belong to the same series. Some shales which were observed in a tank at Dechú, 60 miles west-north-west of Jodhpúr, and about 30 east-south-east of Pokran, may be the same. Some softer shales which occur at Jodhpúr should more probably be referred to the next group.

3. *Jodhpúr sandstones.*—The sandstones which cover a considerable tract of country in the neighbourhood of Jodhpúr are usually coarse in texture and almost always dull red in colour, though occasionally white or brown. As a rule, they are purely quartzose, but they sometimes contain felspar, and in places they are highly micaceous, the mica being arranged in layers, so as to produce a shaley structure. Small pebbles occasionally occur and are chiefly composed of quartz, but the rock is not usually conglomeratic ; it is, however, often obliquely laminated, and the surfaces of slabs are frequently ripple-marked. The beds are quite unaltered and often nearly horizontal, rolling about at low angles.

Except for their being rather softer, there is little, if anything, to distinguish these sandstones from some of those belonging to the Vindhyan series. No rocks of this series have hitherto been detected west of the Arvali hills, the great Vindhyan area commencing several miles to the eastward of that range. The reference of the Jodhpúr sandstones to the Vindhyans is little more than a suggestion ; they resemble the beds of that series more than any other known Indian formation, but it is quite possible that they may belong to a different horizon.

The Jodhpúr sandstones were not noticed south-west of Jodhpúr. They are found for some distance west of the town and for many miles to the northward, their extent in this direction being quite unknown. They are found stretching from Jodhpúr to Pokran, a distance of 90 miles, but much of the intervening country is so completely concealed by sand, that it is impossible to say whether any breaks occur.

4. *Bálmír sandstones.*—The next three groups belong in all probability to the Jurassic series; marine Jurassic fossils being found abundantly in the two upper. At Bálmír and in some hills to the eastward a considerable thickness of sandstones, grits and conglomerates is exposed, the characteristic beds being whitish or grey sandstone, very fine and compact, so compact indeed as to break with a sharp conchoidal fracture, and to have a sub-vitreous lustre on the fractured surface. With these beds coarser and finer sandstones are associated, the finer passing into a compact hard shale, whitish in colour, but sometimes veined and blotched with purple, and at times entirely purple. There are also bands of coarse conglomerate towards the base, containing, at Bálmír, pebbles of the underlying Maláni beds. A few fragmentary remains of plants were found in these beds, but none sufficiently well preserved to be determined with certainty.

Similar rocks, rather less hard, occur near Náosir, Sanpha and Sárun, 30 miles east of Bálmír, the intervening ground being concealed by sand-hills.

East and south-east of Jesalmír, beneath the marine Jurassic beds of the next group, a considerable thickness is exposed of grey, white, and brown sandstones, interstratified with numerous bands of hard black and brown ferruginous sandstone and grit. The base of these beds is not seen, but the lowest strata exposed at Kíta, 15 miles from Jesalmír, on the road to Bálmír, are fine white beds, soft, argillaceous, and slightly micaceous, and stained purple, lilac and scarlet in places. Some of these beds so closely resemble the variegated sandstones of Bálmír that it is probable they are of the same age, and their much greater softness may be due to the smaller amount of disturbance they have undergone. Precisely similar soft white sandstones are found at Láthí, 40 miles east-by-north from Jesalmír, and are doubtless on the same horizon as those of Kíta: at both places fragmentary plant remains are common, but nothing recognizable could be found except some dicotyledonous fossil wood, which occurs at Láthí.

These rocks resemble the Umia beds of Cutch, and they are very similar to some Gondwána rocks, especially portions of the Kámthí and Máhádéva groups.

5. *Jesalmír limestones.*—Above the beds last mentioned are the Jurassic limestones and sandstones of Jesalmír. These consist of sandstones with thick bands of compact, buff and light-brown limestones, one of the most beautiful building-stones in India, and of which much use might be made if it were more accessible. The sandstones vary much, being grey, brown and blackish (ferruginous), sometimes calcareous, and occasionally interstratified with bands of conglomerate, containing pebbles of quartzite, red jasper, and ferruginous sandstone, the last of which looks as if derived from the underlying group. Some other forms of limestone occur, and in one place a grey rock abounding in shells is found.

The limestones contain numerous fossils. Specimens of *Ammonites* (*Stephanoceras*) *fissus*, Sow., were obtained from the natives at Jesalmír, but the exact locality could not be determined; there can be little doubt, however, of its being in the neighbourhood of the town. I found the following species in the limestone scarps; for the determination of several of them I am indebted to Dr. Feistmantel:—

ECHINODERMATA.

*Hemicidaris*, sp.
*Pygurus*, sp.

MOLLUSCOIDA.

*Terebratula biplicata*, Sow.
*T. intermedia*, Snow.
*Rhynconella*, sp.

MOLLUSCA.

*Mactromya*, tp. common.
*Homomya*, 2 sp.
*Pholadomya granosa*, Sow.
*Corbula lyrata*, Sow., common.
*C. pectinata*, Sow., common.
*Trigonia costata*, Sow.
*Nucula cuneiformis*, Sow.
*Modiola*, sp.
*Pinna*, sp.
*Pecten lens*, Sow.
*Anomia*, sp.
*Nerinæa*, 2 sp,
*Natica*, 2 *or* 3 sp.
*Nautilus Kumagunensis*, Waagen.

Many of these are characteristic Jurassic forms, and are found in the Oolitic rocks of Cutch; the two *Cephalopoda*, *Ammonites fissus* and *Nautilus Kumagunensis*, being met with in the Chárí group.

Above the limestones of Jesalmír, sandstones of various colours, frequently calcareous, are seen, but they are not so well exposed as the beds below the limestones, and it is difficult to say whether these upper strata should be assigned to this group or the next.

No unconformity could be detected between the Jesalmír beds and the underlying sandstones which are supposed to represent the Bálmír rocks. The lowest beds of the former are seen in a scarp a few miles south-east of Jesalmír. At the same time the examination made was necessarily cursory, and the existence of a break is rendered probable by the occurrence of pebbles, apparently derived from the lower group, in the conglomerates of the upper.

6. *Ammonite bed of Kuchrí.*—At Kuchrí, two short marches, or about 25 miles west-north-west of Jesalmír, a belt of rocks appears, consisting of dark calcareous sandstones resting on soft white sandstone, and capped by a thin bed of buff and brownish limestone, weathering red where exposed, and abounding in *Ammonites* of a yellow colour, belonging to three or four species, an *Arca*, oysters and other bivalves. None of the *Ammonites* appear to be Cutch species, though one form is near *A. opis*, Sow. Above the limestone is some grey sandstone with hard ferruginous bands of the usual Jurassic character, and upon these beds rests nummulitic limestone.

The relations of the Kuchrí beds to those of Jesalmír is not quite clear, but apparently the former are higher in the series. Still, as no rocks are seen over a considerable proportion of the intervening country, there may be a concealed roll of the strata, or a fault, but it is more probable that the beds are nearly horizontal, with a gradual ascending sequence to the north-west, and unfaulted, because any kind of disturbance would tend to harden the beds and enable them, by resisting denudation, to stand up above the surface.

7. *Nummulitic limestone.*—This was only seen west of Kuchrí. It appears to represent the lowest beds of the Khirthar group at Rohrí, and it rests directly on the Jurassic rocks, no representatives of the lower Eocene (infra-nummulitic or Ranikot group), Deccan traps, or Cretaceous beds of Sind and Cutch being met with.*

8. *Alluvial deposits.*—Exclusive of the Indus alluvium, a large portion of the desert appears to be covered with deep alluvial deposits. This is especially the case in the Lúni valley, and the country south-west of Jodhpúr, but large tracts between Godra and Bálmír, others east of Bálmír, and between Jesalmír* and Pokran, are thickly covered with a sandy deposit, which is doubtless at the surface a comparatively recent formation. Many of these tracts are covered with blown sand, and the wash from the sand-hills is spread over the surface and cannot be distinguished from older sandy deposits. Much of the alluvium, however, appears to be of older date than the blown sand, and to have covered the surface before the sand-hills were formed.

9. *Blown sand.*—An immense area of country is entirely covered with sand-hills, and tracts of blown sand are to be found in numerous places from the banks of the Indus to the Arvali range. Besides the more isolated hills scattered over the country, there are two tracts in especial, in the area traversed between Sind and Jodhpûr, in which the surface is entirely covered with blown sand. One of these, which is known as the Thar, is in eastern Sind, along the edge of the Indus alluvium, and it extends the whole length of

* I have since seen fragments of the same limestone said to have been brought from south of Jesalmír, the locality being probably near Vinjorai.

the province, from the Ran of Cutch to the Baháwalpùr territory. The other tract extends northward or north-north-east, also from the neighbourhood of the Ran, and was crossed east of Bálmír, and again between Jodhpùr and Pokran. It appears to extend towards Bikanìr.

The hills in the western tract are arranged in regular parallel or nearly parallel ridges running nearly north-east and south-west to the southward near Umarkot, while further north, towards Rohrí, they have a direction from south-south-west to north-north-east. The ridges frequently end abruptly with a steep slope to the north-east.

Elsewhere the sandhills are not arranged in parallel ridges, but are more or less thickly scattered over the surface, and have always a steep slope to the north-east and a long gentle slope to the south-west. It is evident that the sand has been transported and deposited by the strong south-west winds of the hot season—May, June, and July. The origin of the parallel ridges is much more obscure, but there can be very little doubt of their being due to the south-west wind*.

The sand consists chiefly of rounded quartz grains, felspar, hornblend and one or two other minerals being also present in small quantities. A portion of it may be derived from the Indus, but a far larger proportion must be due to some other source. Many of the sand-hills are evidently of great antiquity; despite the small rainfall of the desert region, they show signs of considerable denudation in parts, and are cut into deep ravines by the action of water.

It is highly probable that the Ran of Cutch is an old inlet of the sea, which has been filled up by the sediment brought in by the Lúni and other rivers. The presence of a marine mollusk, living in the salt-lakes north of Umarkot, proves that this inlet extended far up the Indus valley, and the great saltness of the soil, both in the Thar and in the Lúni valley, suggest the probability of the sea having extended in both directions. The shore of this great inlet may easily have supplied the blown sand which now covers so large an area of the desert, and the distribution of the sand-hills nearly coincides with what might be expected if the sands were derived from such a source.

Throughout the greater portion of the desert there is no evidence of marine denudation. Nothing of the kind is seen near Bàlmìr, and the scarps near Jesalmír are evidently due to subaërial action, and quite different in appearance from sea cliffs, each being formed by the outcrop of a hard bed. It therefore appears probable that the central region of the desert was above the sea, forming either a promontory or an island, whilst the Ran of Cutch, the Indus valley, and portions of the Lùni valley were under water.

## ON THE OCCURRENCE OF THE CRETACEOUS GENUS OMPHALIA NEAR NAMCHO LAKE, TIBET, *about 75 miles north of Lhassa. By* OTTOKAR FEISTMANTEL, M. D., *Geological Survey of India.*

Last year (1876) the Geological Survey received some fossils from Captain Trotter, which were collected by one of the Pandits attached to the Trigonometrical Survey of India on his route from Ladak (Leh) to Lhassa.†

The most peculiar amongst them appeared to Mr. W T. Blanford, who first received this collection, and subsequently to me, some *Turritella*-like forms, which were especially characterised by two well-marked, prominent ribs in each whorl (in the whole height of the

* See for further details J. A. S. B., 1876, XLV, Pt. II, pp 92,67, &c.
† See sketch-map in Geographical Magazine, June 1876.

shell), by an angular (sinuated) striation of the shell in each whorl, and by the thickness of the shell. The specimens were labelled "Hills near Namcho Lake, Tibet." Other work, especially on the different local floras of India, compelled me to delay the determination for a future occasion.

When later the palæontological collections of the Asiatic Society of Bengal were amalgamated with those of the Survey in the Indian Museum, I found amongst them a much better preserved specimen of the same kind as mentioned above; but no locality was attached, only the inscription "Glauconia" sp.?

This discovery induced me to return to the examination of the Pandit's fossils, and they yielded the interesting result that the fossils belong to that genus, which was established first by Zekeli in his paper on "Gasteropoda of the Gosau formation, 1852" with the name *Omphalia*, Zek., with which *Glauconia*, Gieb., is synonymous.

## *Family: TURRITELLIDÆ.*

### GENUS.—OMPHALIA, *Zekeli*, 1852.

1852. Zekeli Gasteropoden der Gosaugebilde, Abhandl., der k.k., Geolog. Reichsanstalt Wien—1852.

1852. *Glauconia*, Giebel allgemeine Palæontologie, p. 185.

1853. *Omphalia*, Reuss: Kritische Bemerkungen über die von Hern Zekeli beschriebenen Gasteropoden der Gosaugebilde in den Ostalpen. Sitzb. der k, Academ, der Wissensch, Vol. XI, p. 7.

1853. *Idem*, Abstract in Leonhard and Bronn N. Jahrb. f. Mineral, etc., p. 635.

1842-43. *Turritella*, ex parte D'Orbigny, Pal. francaise Gasteropodes, Terrain crétacés, Vol. II. Pl. 152, 153.

1863. *Omphalia*, 3 new species, Drescher Uber die Kreidebildungen der Gegend von Löwenberg, Zeitschr. d. D. Geolg. Gesellsch, 1863, p. 334, Pl. IX, f. 2–7.

1865. *Omphalia*, Dr. Stoliczka,—Eine Revision der Gasteropoden der Gosauschichten in den Ostalpen. Sitzb. d. k. Acad. d. Wiss. in Wien., 1863, p 11.

1865. *Cassiope*, (replacing or including *Omphalia*, Zekeli) Coquand, Monograph de l'étage Aptien de l'Espagne, p. 57, Pl. III, IV.

1867. *Glauconia*, Stoliczka, Gasteropoda of the cretaceous rocks of Southern India, Pal. Indica, vol. v., 1867, p. 209, et sequ.

I think I am right, using the generic name *Omphalia*, as Zekeli established it, and not *Glauconia*, Giebel, which was published, it is true, in the same year, but Zekeli's paper was presented already, partly at least, in 1851, although published only in 1852.

Prof. Reuss and Dr. Stoliczka, in their papers 1853 and 1865, did the same, only in 1868 Dr. Stoliczka adopted, in contrast with his paper of 1865, the genus *Glauconia*, including *Omphalia*, Zek.

Quite unnecessarily and superfluously M. Coquand, 1865 (l. c.), established a quite new genus *Cassiope*, uniting with it, without sufficient grounds, Zekeli's *Omphalia*. Zekeli first gave most figures of this genus, and so his name is to be used by all means.

The characters of the genus are the following :—

"The shell is always shortly conoidal or turreted, very thick, with spiral ridges or ribs; the columella generally hollow, aperture round-ovate; the exterior lip with two emarginations, of which one lies above, or rarer in the middle of the right labial margin, the other on the base. The striæ of growth are sinuated (waved) according to the emargination."

As to the systematical place, it seems that *Omphalia* is mostly related with the *Turritellidæ*, although it presents also some similarity with the *Melanidæ*, and Dr. Stoliczka l. c. p. 211 (1867) considers it as a truly intermediate form between these two families, although he describes it at the beginning of the *Turritellidæ*.

The difference from *Cerithium* is established by the form of the aperture and the complete want of any canal to the aperture.

In Leonhard and Bronn N. Jahrb. (1853) p. 636, a relation with *Nerinea* is mentioned as possible. But *Nerinea* has such a constant appearance in the faults on the columella and in the more rhomboidal aperture, that forms of it can scarcely be mistaken.

Also in comparison with *Turritella* there are differences enough. The shell of *Turritella* is always higher and more accuminate, thinner, has no real columella and an emargination in the exterior lip is not constant, and when present, always shallower and the striæ of growth therefore are never so waved.

As to the "conditions of living" of the *Omphaliæ*, Dr. Stoliczka already, in his revision of the Gosau Gasteropoda (l. c., p. 15), stated that the *Omphaliæ* in the Alps are characteristic of coal-bearing strata,—and he concludes that they appear to be inhabitants of brackish or fresh water (Pal. Ind. l. c., p. 211), or at least more littoral (Revision l. c., p. 15), by which the construction and structure of the shell is well explained.

The genus *Omphalia*, Zek., is at present with certainty known mostly only from cretaceous rocks: from Aptien, Cenomanien, and Gosau.

A representative, as the oldest, is known from Wealden. In the Gosau, Zekeli described nine species, which Dr. Stoliczka reduced to four, but there are to be added still three of D'Orbigny's *Turritella*, i. e., *Turritella Renauxiana*, *T. Requieniana*, and *Turr. Bauga*,* further Coquand's species of *Cassiope* are to be placed here. Three species are described by M. Drescher (l. c.), but all distinct species are cretaceous.

Our species is very well marked and different from the others known, so that I will describe it as follows:

### OMPHALIA TROTTERI, *Fstm.* Pl. I, f. 1—4.

*Testa conica turrita, oblonga, umbilicata apicem versus attenuata, hoc modo lateribus paulo incurvata; anfractibus septem et pluribus; omnibus duas tantum costas distinctissimas continentibus, ultimo in solum tertia costa apparente; costis anfractorum et spatiis inter eos differenter (undulatim) striatis; apertura oblonge rotunda, columella glabra.*

*Measurements of the specimens.*

*a.*—Specimen fig. 1:

| | |
|---|---|
| Spiral angle, apical portion | 46° |
| apertural portion | 30° |
| Sutural angle | 108° |
| Total height... | 46 mm. |
| Height of the last whorl | 16 mm. |
| Height of last whorl to total of shell (taken 100) | $\frac{35}{100}$ |
| Breadth (below) | 26 mm. |

* In his Cretac. Gasteropoda of S. India Dr. Stoliczka considers this species again as *Turritella*.

*b.*—Specimen fig. 2:

| | |
|---|---|
| Spiral angle apical portion | 46° |
| apertural portion | 26° |
| Sutural angle | 106° |
| Total height | 62 mm. |
| Height of the last whorl | 23 mm. |
| Height of last whorl to total length | $\frac{37}{100}$ |
| Breadth | 31 mm. |

*c.*—Specimen fig. 3, (fragment.)

| | |
|---|---|
| Spiral angle, apertural portion | 17° |
| Sutural angle | 100° |
| Height of fragment | 44 mm. |
| Height of specimen restored | 95 |
| Height of last whorl | 21 mm. |
| Proportion of last whorl and total height | $\frac{22}{100}$ |
| Breadth | 35 mm. |

*d.*—Specimen fig. 4:

| | |
|---|---|
| Spiral angle | 34° |
| Sutural angle | 104° |
| Height of fragment | 47 mm. |
| Height of shell restored | 57 mm. |
| Heigth of last whorl | 16 mm |
| Proportion of height of last whorl and total of shell | $\frac{28}{100}$ |
| Breadth | 25 mm. |

*Description:*—The shell is conical turreted, oblong, umbilicated; it is not quite regular in the whole height, but it becomes more attenuated towards the apex, so that in the upper part it is a little incurved; there are seven or more whorls bearing the chief character of the shell, two very distinct ribs, thickest in the lowest whorl and becoming thinner towards the apex. Only in the lowest whorl a third rib appears.

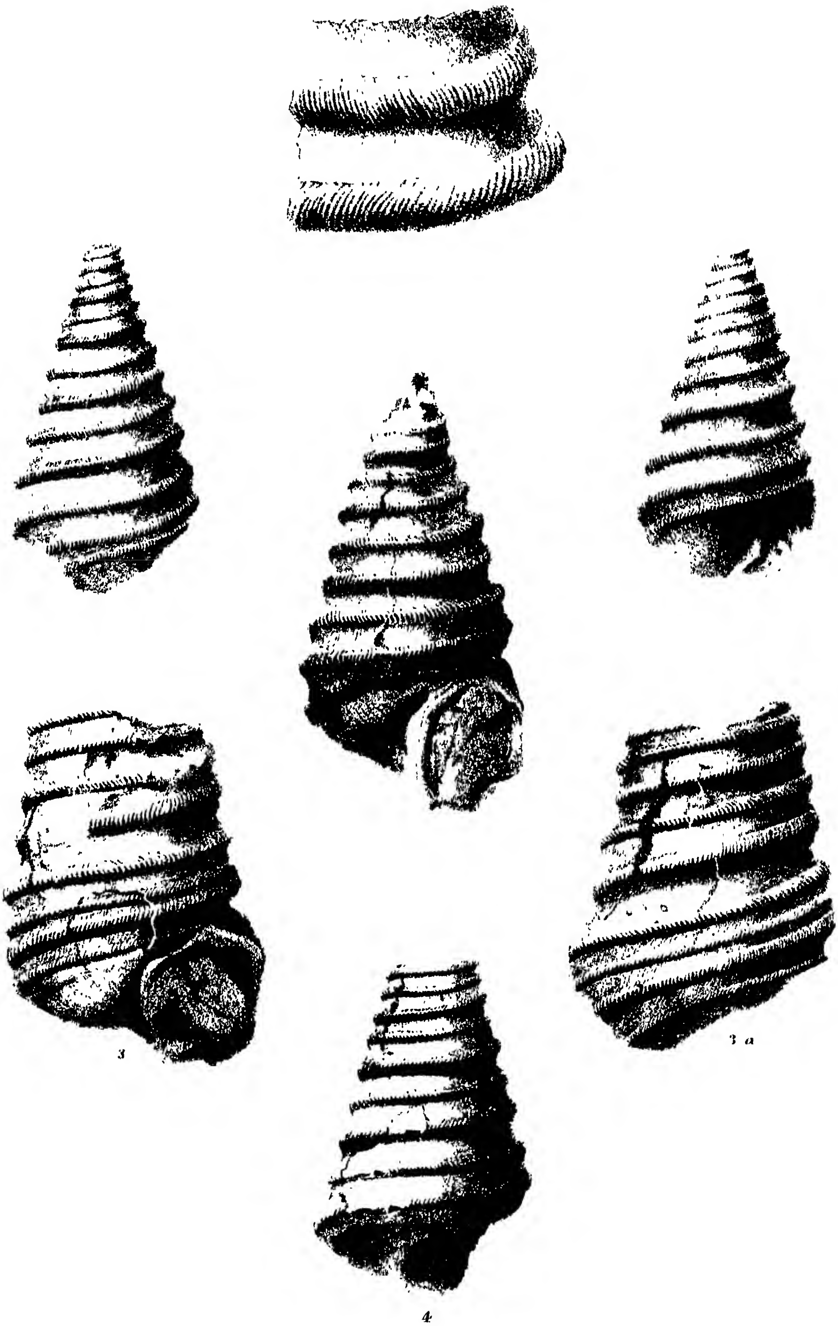
The ribs and spaces between are characteristically marked by the striation of growth, which is perfectly sinuated, and in such a manner that the lower rib, with which the whorl begins, and the next space are striated in a contrary way to that of the next rib and the following space, and so on to the apex; from this we can conclude that the emargination of the aperture was between the first and second ribs.

The aperture is oblongly round.

When we consider the measurements of the specimens, we find a spiral angle at the apical portion of 34°—46°, at the apertural of 17°—30°; the sutural angle 100°—108°; the height of specimens from 46—95 mm., height of last whorl from 16—23 mm., and the proportions of these to the total length from $\frac{22}{100}$—$\frac{37}{100}$; the breadth (below) from 25—35 mm.

These measurements enable us to compare our specimens with forms already described, but to distinguish them also.

From the measurements it follows that our species has much shorter whorls than all those described by Zekeli, the proportion of the last whorl to the total height being much smaller.



3

3 a

4

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Also those specimens figured in D'Orbigny and Coquand, and those recently described by M. Drescher (l. c.) have higher whorls.

In the other dimensions our species agrees mostly with *Omphalia Kefersteini*, Munst. spec., to which also *Omphalia suffarcinata*, Munst. spec., is to be placed.

With these our species is also otherwise related; but different by the two very well marked spiral ribs in each of the whorls, of which one runs on the lower part of the whorl, and the other in the middle of it, while in *Omphalia Kefersteini*, Munst. sp., still a third rib runs on the upper part of the whorls.

I named the species after Captain Trotter, who has presented the specimens to our museum.

As *Omphalia* as yet is known almost only from cretaceous, and mostly from upper cretaceous, we have to consider our form also as most probably of upper cretaceous age.

Cretaceous rocks in the Himalayas are known with certainty still only from Spiti, described by Dr. Stoliczka as the Chikkim limestone in his paper on North-West Himalaya in Mem. Geolog. Surv. India, Vol. V, p. 116. But only several fragments of *Rudistes* and numerous *Foraminifera* were observed.

From these fossils we had certainly to look upon the Chikkim limestone as a marine formation, while the beds near Namcho Lake with *Omphalia* were littoral or brackish.

Some rocks of cretaceous age occur in the Kasia hills, near, but quite detached from, the eastern Himalaya.

NATICA species.

From about the same locality are three other specimens of *Gasteropoda;* from the general form one can judge with much probability that they belong to the genus *Natica*, they are however imperfect just at the aperture, and none of them shows this portion sufficiently. The specimens are of a large size and all more or less compressed, as are also several of the specimens of *Omphalia*.

We know *Natica* occurs in most of the formations, and it is therefore most probable that the specimens under discussion are out of the same beds as *Omphalia Trotteri*, Fstm., *i. e.*, from *upper cretaceous* rocks.

*Explanation of Plate.*

Figs. 1, 1*a*, 1*b*.—*Omphalia Trotteri*, Fstm. Specimen with unknown locality, amongst the collections of the Asiatic Society of Bengal.

Figs. 2—4.—The same species. Specimens sent by Captain Trotter, and collected near Namcho Lake, Tibet.

NOTE *on* ESTHERIA *in the* GONDWANA *formation, by* OTTOKAR FEISTMANTEL, M.D., *Geological Survey of India.*

Recently, a very interesting paper was sent to me by Prof. Geinitz (Dresden) on some fossil plants and animals from the Argentine Provinces—La Rioja, San Juan, and Mendoza.* From the total of the fossils described by Prof. Geinitz, he declares the series to be of Rhætic age. This paper has induced me to examine again our *Estheria*-bearing rocks, and to compare them together regarding their homotaxical position.

1.—*Estheria in the Mángli beds.*

In the American Rhætic beds, M. Geinitz recognized, as very abundant and characteristic, an *Estheria*, which was first described by Mr. Rupert Jones† from Mángali (Mángli), Central India, between Nágpúr and Chánda, about 60 miles S.-S.-E. from the former place.

The argillaceous sandstones at Mángli contain very few other fossils, except that *Estheria* and another of much smaller form, which is as frequent as the *E. Mangalensis*, but remained undetermined. Thus, the position of these Mángli beds has remained always somewhat uncertain, although Mr. Jones thought there were reasons to consider the beds as Rhætic, which is most probably the case.

From the common occurrence of this smaller form of *Estheria* in the Mángli beds and in the Panchet group, Mr. W. T. Blanford first considered the Mángli beds as belonging to the Panchet group;‡ but in his later paper on the "Geology of Nágpúr,"§ he set aside this evidence as insufficient, and finding no stratigraphical feature whereby to separate them, he left these beds in the Kamthi group, which, without any doubt, is analogous with the Raniganj group, forming the upper part of the Dumuda series, both having the same *Phyllotheca indica*, Bunb. (the real leaved branchlets), *Vertebraria indica*, Bunb., *Glossopteris communis*, Fohn., *etc.* In a recent detailed survey of the Wardha coal-field, by Mr. Hughes,|| the Mángli beds are still left in the Kamthi group, there being no physical grounds for a separation. This should only encourage us to seek help from palæontology.

Considering that the Damuda series, in general, contains very frequently plant fossils and is especially characterized by the occurrence of *Glossopteris*, which is till now the only character of it, as *Schizoneura*, with the same species, is also numerous in the Panchet group, and that not a trace of these fossils is found at Mángli; on the other hand, that the Mángli beds contain mostly only that mentioned *Estheria*, which, with exception of Kawarsa, of which I speak further on, is nowhere found in the Damuda series, but only in younger strata, it will be perhaps advisable to look for another place for these Mángli beds; it seems to me that they are to be taken at least of the age of the Panchet group, or even still younger.

First, the plant fossils. These are very poor, and consist till now only of some stems, which have no relation with any of the Damuda fossils, but with younger forms:

*a. Palissya.* A stem fragment figured in Sir Ch. Bunbury's Nágpúr flora,¶ Pl. XII, f. 1, as "*Knorria?* (Portion of stem of a *Conifer?*)" is certainly a coniferous plant, as is well seen from the relation of the scars. I have an original specimen of the same, and I am convinced that it belongs to the fossil *Palissya* and most probably *Pal. Brauni.*, Endl.

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* Beitrag zur Geologie und Palæontologie der Argentinischen Republik.

I. Palæontologischer Theil. II Abtheilung: Über Rhätische Pflanzen und Thierreste in den Argentinsichen Provinzen—La Rioja., San Juan, und Mendoza. Von Dr. Hanns Bruno Geinitz Cassel 1876.

† Jones' Monograph of the fossil Estheriæ, Palæontogr. Soc., 1862, p. 78.

‡ Mem., G. S., Vol. III., p. 134.

§ Ibidem IX, p. 32 (3 ib.)

|| Ibidem XIII.

¶ Quart. Journ. G. S., London, XVII.

*b.* "*Truncus filicis.*" Another stem is figured in Sir Ch. Bunbury's paper (l. c.) Pl. XII, 2, and marked "*Stigmaria ?* (Portion of the Rhizome of a fern.)"

This Mángli stem is certainly a fern stem, and is very similar to those M. Schenk described as "*Trunci filicum*" from the Rhætic beds in Bavaria. I have an original specimen in our collection from Veitlahm in Bavaria, which is almost identical with that figured from Mángli in Sir Ch. Bunbury's paper.

Besides these two mentioned forms, there are only some indistinct stems known.

Instead of an abundant flora, we find as very numerous the shells of little crustacean animals; there are certainly two forms, a larger and a smaller one.

*a. Estheria Mangaliensis*, Jones.—(See: Jones—Palæontograf. Soc., 1862. Monograph of fossil Estheriæ—p. 78, Pl. II. f. 16-23, and Geinitz l. c. Uber Rhätische Pflanzen und There etc.,—Pl. I. f. 1-6. p. 3). This is the larger form, which Mr. Jones described first from Mángli; we have numerous pieces of rock from there, on which this form lies abundantly. On some specimens *E. Mangaliensis* is only represented, while on some others it is mixed with the other smaller form, and still, on some others, this later only is predominant.

Jones gave several figures, which all indicate the larger form *E. Mangaliensis* J. As to the age, Mr. Jones considered these beds, for certain reasons, as Rhætic and now Prof. Geinitz describes the same species from beds of the same age in South America.

*b. Estheria comp. minuta* var *Brodicana*, Jones. This form was not described; it is, however, as frequent as the larger one. From the size and form, and from the structure of the shell, they can safely be taken as very closely allied to *Estheria minuta* var. *Brodicana*, Jones),* which, as Mr. Jones indicated so distinctly and exhaustively, is characteristic of the Rhætic beds.

This smaller form the Mángli beds have in common with the Panchet group, and to judge only from the *Estheria*, an animal fossil, we may consider both on the same horizon, to which view, in the case of Mángli beds, there is no objection; but as also no plant of the Panchet group is found in the Mángli beds, the former being closer connected with the Damudas by the *Schizoneura*, while in the Mángli beds the plant-remains are very poor, and most naturally referable to Rhætic fossils, I consider, as most probable, that the Mángli beds cannot belong to the Damuda series at all, and that they are rather to be considered as the uppermost continuation of the Panchet group.

Already Mr. Hislop himself has pronounced, 1864, quite distinctly that the *Mángli beds* are to be placed above the plant-bearing beds at Nágpúr (Q. J. G. Soc., 1864, pp. 117 and 282.

The Mángli beds have yielded also a Labyrinthodont Reptile, which is described by Owen as *Brachyops laticeps*, Ow. (Q. J. G. S., 1855, p. 37, Pl. II). But this is, of course, no objection to the view I suggest, as it is well known that Labyrinthodont Reptilia occur also in the Keuper of Europe.

### 2.—*Estheria in the Panchet group.*

In the Panchet group, besides pretty numerous plant fossils, an *Estheria* also occurs, which is certainly identical with the smaller form of *Estheria* in the Mángli beds, mentioned as *Esth. minuta* var. *Brodieana*, Jon. I compared specimens from both localities, and I could not find any difference.

* Jones, l. c., Pl. II.

Amongst the other fossils two ferns especially prevail, *i. e.*, *Pecopteris concinna*, Presl. and *Cyclopt. pachyrrhachis*, Göpp., which are Rhætic forms ; so that one might take the Panchet group of this age—only the occurrence of the *Schizoneura Gondwanensis*, Feistm. identical with the same in the Raniganj (Kamthi) group of the Damuda series, induced me to consider the Panchet group a little older, as representative of the upper Triassic (Keuper) strata in Europe.

The reptilian remains in this group, besides the plant-remains, are also pretty frequent; and are not at all opposed to the evidence from the plant-remains; they belong mostly to the *Dicynodont* reptiles, which first were known from South Africa, where, however, their age up to the present day remains undecided.

Here, in India, however, where we know that the Panchet group overlies immediately the Raniganj group, which itself is lower Triassic, and underlies the Rajmehal group, which is, to say the least, Liassic, and where, besides the reptiles, a flora occurs, which agrees with a flora from defined strata, there can, I think, be little doubt about the homotaxical position.

In the Panchet group, therefore, the flora is additional evidence as to the age of this group, and the Panchet *Estheria* is identical with the small form in the Mángli beds. It was therefore more natural when Mr. Blanford* first took the Mángli beds as belonging to the Panchet group. I must, however, state again that no other fossil of this group, except the small form of *Estheria*, is found in the Mángli beds; and judging from the absence of *Schizoneura*, which only induced me to class the Panchets as Keuper, my conjecture, that the Mángli beds are the top of the Panchet group, is perhaps not unnatural. There are, at least as far as I know the relations, no contradictory indications.

### 3.—*Estheria from Kawarsa.*

The Kawarsa beds also are in the Wardha basin, and have been mapped, like the Mángli beds, with the Kamthi group. The Màngli beds occur at the top of the section, at the northern edge of the area, immediately under the Deccan trap. Mr. Hughes estimates the whole thickness to the base of the Kamthis as 700 feet. This is an extraordinarily small thickness for the period this series is supposed to represent, and considering that in a neighbouring region, below the Kota-Maléri beds, on the Godavari, there is an apparent accumulated thickness of 17,000 feet of these 'Kamthi' strata, it is certainly not too soon to endeavour to indicate horizons in such a mass of deposits. The Kawarsa beds occur near the southern margin of the basin, and Mr. Hughes speaks of them as several hundred feet from the the base of the series. They have yielded some broken plant-remains and *Estheria*.

*a.*—An *Equisetaceous* stalk, pretty distinct; it belongs to that group of forms which generally are termed *Phyllotheca*, which, however, as I have already mentioned, belong to a great extent also to *Schizoneura*, Schimp., and the more so, as *Phyllotheca* in the real sense is not so frequent as *Schizoneura*, Schimp.

*b.*—A fragment of an oblongly lanceolate leaflet with marked ribs, which might belong to *Schizoneura*, Schimp.

*c.*—Some broken specimens of *Glossopteris* occur very rarely in comparison with these so richly represented leaves at Nágpúr and elsewhere in the Damudas; and I have no doubt that these beds, near Kawarsa, are younger than all the real Damudas, including the Kamthi-Raniganj group.

* Mem., Geol. Sur., III, p. 134.

To this indication now is to be added the occurrence of ***Estheria***, which is certainly identical with that in the Panchet group, the state of preservation and the size and form being identical; and is therefore to be considered as very likely ***Estheria minuta*** var. ***Brodieana*** Jon.

From this occurrence of the ***Estheria***, an animal fossil which is still so frequent in the Mángli beds and in the Panchet group, and from the scarcity of plants altogether, and from the state of the rock, it would, I think, follow that the locality at Kawarsa is scarcely to be considered as representative of any group of the real Damuda beds, the fossils of which are everywhere so different from those both of the Mángli and the Kawarsa beds.

It must thus be admitted that this blending of the fossil forms indicates transition, and affords some support to the continuity of the stratigraphical characters in this area, whereby the whole has been mapped and published as a single rock-group; an abridged representation of the top of the lower Gondwarra series, in which the Panchet and upper Damuda groups are very closely connected.

The possible persistence of two *Estheria* horizons (as is known to occur in Europe) may, however, be worth suggesting—an upper, with two *Estheria* (Mángli), and a lower, with the *Estheria minuta* (Panchet and Kawarsa).

### 4.—*Estheria in the Kota beds.*

From the Kota beds on the Pranhíta, near Sironcha, Mr. Jones described also a species of Estheria as *Estheria Kotaensis*, Jones.*

The Kota locality and the neighbouring one of Maléri (Maledi) have long been famous in Indian geology for fish and crocodilian remains. The general relations of these deposits have recently been approximately fixed by the Survey. They rest upon the Kamthi beds, with more or less of unconformity, at the south end of the Wardha coal-field; extend thence down the valley of the Pranhíta to Sironcha, on the Godavari, where they again overlie an immense thickness of rocks of Kamthi aspect. But for the prevalence of red and green clays, and the frequent occurrence of a limestone, they are not themselves strikingly different in mineral character from the Kamthi type; which again, as has been often remarked, has many resemblances to that of the original Panchet group of Bengal. On this account, and from the decidedly Keuperic affinities of the majority of the vertebrate fossils of Maléri, the beds here have been hitherto regarded by the Survey as probably on the Panchet horizon; the Kota limestone, from its fish-remains, being taken as Liassic and thus presumably younger. Mr. Hughes has shown that the beds of both localities are on the same horizon, and the formation is now known as the Kota-Maléri group.†

Amongst the numerous additions to our collections of vertebrate fossils from these beds, made by Messrs. King and Hughes, there were a very few plant-remains, of which I have determined two from Maléri as common species of the Kach-Jabalpur horizon, and one, from a bed underlying the Kota limestone, as a familiar species of the Rajmahal group. It may not be established that the circumstances of position indicate a permanent distinction of these two groups in this region, as I have already shown that in their typical areas they have some forms in common. But at all events, these plant fossils go far to establish the position of the Kota-Maléri beds in our Indian series,—that they are not Panchet, but Upper Gondwana, on or above the horizon of the Rajmahal group.

This connection of the Rajmahal group with the Kota-Maléri beds is significant, so far as the strongly Rhætic affinities of the vertebrate fossils confirm my determination

* Monograf of Esther, l. c., p. 81, Pl. II, f. 24-25.

† See Hughes, Mem., Geol. Survey.Vol. XIII, p. 81.

of the Rajmahal flora as at least lower Liassic. The *Estheria* may perhaps be taken as an indication in the same direction. This *Estheria Kotaensis* may now also be taken as an Upper Gondwana form.

As the *Estheria* has hithero been neglected in India in the discrimination of horizons' I would add some illustrations of the service it has rendered elsewhere.

*Estheria minuta,* Jones, is a splendidly guiding fossil of the whole *Keuperic* strata in Europe. A variety of this species—*Esth. minuta,* var. *Brodieana,* J.—is characteristic of the Rhætic strata. The well-known Prof. Römer, only with the assistance of *Estheria minuta,* var. *Brodieana,* Jon., decided that certain rocks in Upper Silesia belong to the Rhætic group. He says in his valuable work, "Geologie von Oberschles," on p. 175, discussing the fossils of certain series, which he calls "Hellwalder Estherien Schichten," as follows (I give the translation):—"Except *Estheria minuta,* Jones, no organisms were observed in that series. But also by itself the little crustacean is of great importance for the determination of the age of this formation. *Estheria minuta,* J., is a very common fossil in the Keuper. A variety, *Esth. minuta,* var. *Brodieana,* J., which is marked by a smaller size and a finer reticulation in the sculpture of the shell, is according to Jones' explanation characteristic of the Rhætic strata. The Upper-Silesian form agrees very well with the figures of this variety." And from this and from some other characteristics, Prof. Römer draws the correct conclusion that those beds in Upper Silesia alluded to are of Rhætic age.

Our *Estheria* of the smaller size does not differ much from that Silesian one. Thus, two species are characteristic of certain series; and there are more of them.

Now Prof. Geinitz describes *Estheria Mangaliensis,* Jones, again from Rhætic strata, in South America. Prof. Rupert Jones has certainly not in vain devoted a monograph to the fossil *Estheria.*

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## NOTICES OF NEW AND OTHER VERTEBRATA FROM INDIAN TERTIARY AND SECONDARY ROCKS, *by* R. LYDEKKER, B. A., *Geological Survey of India.*

The present paper contains short notices of several species of Vertebrata from the Tertiaries and Secondaries of India, which are either new to science, or of which some new point in the osteology or distribution is now for the first time noticed; the new species will be subsequently figured and described in the "Palæontologia Indica," although some of these descriptions will not appear for a considerable period.

### BOS ACUTIFRONS, n. sp., nobis.

This species is founded upon a cranium from the Siwaliks; it may be defined from the characters of the cranium as follows:—

Frontals convex, longer than broad, horn-cores placed immediately above occiput, compressed, convex superiorly, extending at first upwards and outwards, with a slightly inward curve at their tips; centre of forehead more prominent than bases of horn-cores; span of horn-cores when complete nearly nine feet; occipital crest narrow, rounded, and extending upwards almost to the intercornual ridge.

### BOS PLANIFRONS, n. sp.

This species also is known by a single cranium from the Siwaliks, of smaller size than the last; it may be defined as follows:—

Frontals nearly flat, longer than broad, horn-cores placed above occiput, slightly compressed, convex superiorly directed outwards, slightly upwards, and at the tips inwards;

centre of forehead not in advance of bases of horn-cores; the latter shorter than in last species; occipital crest broad and narrowed, and separated by a considerable interval from the intercornual ridge.

BUBALUS PLATYCEROS, n. sp., nobis.

Frontals nearly flat, rounded superiorly, horn-cores triangular, placed in advance of the plane of the occiput, superior border concave, directed upwards and outwards, tapering rapidly, widely separated at their bases; exterior face continuous with the plane of the frontals; occipital crest broad and rounded, entirely distinct from the intercornual ridge This species is also from the Siwaliks.

STEGODON GANESA, F. & C.

A tusk of this species from Biltari in the Nerbudda valley has been for a long period in the Indian Museum, though the species has never been described from the Nerbudda deposits; it comprehends the greater portion of the middle part, and is from the left side; it is characterized by being laterally compressed, and by the extremity curving upwards and inwards; in the above points, and in its size, it exactly corresponds with the tusk of Colonel Baker's cranium of *S. ganesa*. The dimensions are as follows:—

| | Feet. | Inches. |
|---|---|---|
| Length of fragment along concave upper border ... ... ... | 6 | 7 |
| Length of chord of arc ... ... ... ... ... | 6 | 1 |
| Vertical diameter near proximal extremity ... ... ... | 0 | 8·5 |
| Transverse ditto ditto ... ... ... ... | 0 | 7·3 |
| Vertical diameter at distant extremity ... ... ... ... | 0 | 6·7 |
| Transverse ditto ditto ... ... ... ... | 0 | 4·7 |

The base of the tusk is absent, and must have been of considerably larger diameter than our fragment, perhaps as large as that of the tusk of Colonel Baker's specimen of this species, which has a vertical diameter of nearly ten inches. The tusks of *S. insignis* are never more than three or four inches in diameter, while those *Elephas namadicus* are usually of about that size, but are occasionally larger. The largest known cranium of the latter species is in the Indian Museum; it is described by Dr. Falconer in the Catalogue of the Asiatic Society's Collection, p. 235. The largest diameter of the incisive sheath of that specimen is 6·6 inches; this being the transverse diameter, the vertical diameter is somewhat smaller. The shape of the incisive sheath, as well as its small size, shews that the tusk in question could not have belonged to *Elephas namadicus*, since the above-mentioned cranium, of the latter species, in the Indian Museum, belonged to an unusually large individual. The cranium to which the tusk under discussion belonged must have had an incisive alveólus, of which the vertical diameter was at least nine and a half inches. The exact agreement, both in form and size, of our specimen with the left tusk of Colonel Baker's gigantic cranium of *Stegodon ganesa*, now in the British Museum, is of itself amply sufficient to prove that our Nerbudda specimen belonged to that species. We have no complete tusks of *Elephas namadicus* in the Indian Museum, but such fragments as we possess indicate that these tusks were nearly straight and cylindrical, and therefore quite unlike the present specimen. The large size of our specimen sufficiently distinguishes it from *Stegodon insignis*.

The range in time of *Stegodon ganesa* must now be made equivalent to that of the allied *Stegodon insignis*, which lived down to the Nerbudda period, and must have been a contemporary of the early human inhabitants of India.

SIVALHIPPUS THEOBALDI, n. gen., nobis.

This genus is formed upon the evidence of a portion of the left maxilla with teeth of an aberrant horse lately sent down by Mr. Theobald from the Siwaliks of Keypar in the

Punjab. The specimen contains the four anterior teeth of the molar series, which have only just come into wear; only a short notice is here given of these teeth, as they will subsequently be figured and fully described.

The first premolar is very small; it is inserted by a single fang; the three succeeding teeth are inserted by distinct fangs, and their crowns are consequently extremely short; their grinding surfaces are oblong, their antero-posterior diameter being the longer of the two; the second tooth is elongated. The larger teeth consist of six lobes, of which the outer and middle pairs are the larger, the latter pair being concave externally; the antero-internal lobe is placed between the two median lobes, and is entirely unconnected with them; the postero-internal lobe is connected by a narrow bridge with the postero-median lobe; the medial enamel infolds are deeply crenulated, and all the hollows are filled with cement; the length of the three large teeth is 3·05 inches; the length of the penultimate tooth is 1·25 inches, and its breadth 0·9 inch.

The teeth approach nearest to those of *Hippotherium*, but are distinguished among other characters by their elongated crowns, and by being inserted by distinct fangs as soon as they are protruded; in the latter character they agree with the American *Protohippus* and *Merychippus*, but are distinguished by having the antero-internal column detached from the antero-median column.

The completeness of the median columns distinguishes these teeth from those of *Anchitherium* and its kindred.

The generic name is derived from the name of the beds in which the specimen was found, and the specific name is given after Mr. Theobald, the discoverer of this and so many other Siwalik fossils.

An examination of the remains of Siwalik *Equidæ* in the Indian Museum has convinced me that, besides the above new genus, there are two species of true *Equus* from these deposits,—namely, *E. sivalensis*, and a new species; and that there are also two species of *Hippotherium*,—namely, *H. antilopinum*, and a larger new species. Two detached middle molars of the latter species are figured by H. von Meyer in the fifteenth volume of the German Palæontographica, under the name of *Equus primigenius* (=*Hippotherium gracile*); a more complete series of the dentition of this species enables me to state that it is certainly distinct from the European species, which must consequently be expunged from the lists of Indian fossils. A memoir on the dentition of all the Indian fossil *Equidæ*, in which the new species will receive names, will subsequently appear.

### ICTITHERIUM SIVALENSE, n. sp., nobis.

The above genus of Viverroid carnivores was first made known to science by M. Gaudry, who determined two species from the upper miocene of Attica; two fragments of the mandible of a Viverroid carnivore, lately sent down by Mr. Theobald from the Siwaliks of the Panjab, appear to agree very closely with the lower jaw of the European *I. robustum*, and I have accordingly referred them to that genus with the specific name of *sivalense*.

The two fragments are respectively from the right and left sides, and probably belonged to the same individual; the larger of the two comprehends the hinder half of the left ramus, lacking the condyle and the coronoid and angular processes; it shews the sectorial molar, the socket of the second molar, and the greater part of the ultimate premolar; the smaller fragment comprises a portion of the middle of the right ramus shewing the two last premolars.

The jaw is arcuated on the inferior border, and is of great depth; the sectorial molar has two outer lobes,—an accessory lobe on the inner side of the second of these lobes, and a talon; the premolars have the same general form as in *Ictitherium;* the crown of the last molar is not shewn. The length of the sectorial molar is 0·7 inch, of the last premolar 0·57; the depth of the jaw is 0·97 inch; the specific differences between this species and *I. robustum* will be subsequently pointed out.

The lower jaw of this genus is distinguished from that of *Hyæna* by the presence of two molars; from *Gulo* and *Putorius* by the presence of the inner lobe on the sectorial; the dental formula of *Ictitherium* is the same as in *Martes* and *Vivena*, but the jaws of the two latter genera are much more slender, and the form of the teeth is also somewhat different.

### Dinotherium and Antoletherium.

Among a collection of specimens lately received in the Indian Museum from the Asiatic Society, the original lower jaw, from a drawing of which Dr. Falconer founded the genus *Antoletherium*, has been discovered. Dr. Falconer's notes on the drawing will be found in the "Palæontological Memoirs" (vol. I, p. 416), where a copy of Colonel Baker's drawing is also given (Pl. 34). This drawing, however, is incorrect; the centre tooth (B) should have three in place of two transverse ridges, while the tooth on the right (C) should have but one ridge. From a note on page 417 of the Palæontological Memoirs it seems that Dr. Falconer subsequently received a correct sketch.

In the same collection, I have also found a portion of a lower jaw with two slightly worn molars from the Siwaliks, which undoubtedly belongs to *Dinotherium*, but which is remarkable for having an incomplete longitudinal ridge between the transverse ridges of the molars, which when worn down would resemble the pattern of the molars of the so-called *Antoletherium;* a smaller and less complete ridge is found in the lower molars of *Dinotherium giganteum*. No other animal but *Dinotherium* has a single three-ridged tooth between two-ridged teeth, as occurs in the so-called *Antoletherium*.

I think that there can be no doubt but that the lower jaw, to which the name of *Antoletherium* has been applied, really belongs to *Dinotherium*, and that the former name must be abolished. The central tooth (1st molar) of the Attock jaw agrees precisely in size with the first upper molar of a *Dinotherium* from the same locality noticed by Falconer, on page 414 of the first volume of the "Palæontological Memoirs," and which I have figured as *D. pentapotamiæ* in a forthcoming number of the "Palæontologia Indica:" the two doubtless belong to the same species. The jaw in question affords additional proof of the specific distinctness of the Punjab *Dinotherium;* both of the re-discovered specimens will be subsequently figured in the "Palæontologia Indica."

### os Sivalensis, Falc. and Cant.

Mr. Theobald has lately sent down a nearly perfect mandible of this species, which is exceedingly important, as it shews that, from the incompleteness of his specimen, Professor Owen was led astray in assigning the teeth to their proper position in the series. The new specimen shews the three true molars, and the sockets of the premolars; the last molar has a circular crown, and is not shewn in the specimen figured by Professor Owen in his Odontography (Pl. 131). From the absence of this tooth, Professor Owen considered the second molar as the last of the series, the carnassial as the second molar, and the last premolar as the carnassial (*Odontography*, p. 504). The new specimen shews that the carnassial is much larger than any of the other teeth, and that the form of the last molar agrees more nearly with the same tooth in the true Bears than was the case according to Professor Owen's interpretation of the homologies of the teeth. A figure of the new specimen will appear in the "Palæontologia Indica."

MERYCOPOTAMUS DISSIMILIS, Falc. and Cant.

Since publishing my notes on the Osteology of this genus, in the last volume of the "Records" (p. 144), I have had an opportunity of comparing the axis vertebra and the astragalus of *Merycopotamus* with the corresponding bones of *Hyopotamus bovinus* from the upper eocene of Bracklesham, and find that these bones of the two genera are so close in form as to be almost undistinguishable one from the other, and were it not for the evidence of the skull and teeth, they would at once be referred to the same genus. I give here the dimensions of the axis and astragalus of *Hyopotamus*, which may be compared with those of the same bones of *Merycopotamus* given on pages 151 and 152 of the last volume of the "Records":—

*Axis Vertebra.*

| | Inches. |
|---|---|
| Length of centrum ... ... ... ... ... ... | 2·9 |
| Width of posterior surface of ditto ... ... ... ... | 1·2 |
| Depth of ditto ... ... ... ... ... | 9·5 |
| Width across anterior articular facet ... ... ... ... | 2·6 |
| Length of odontoid process ... ... ... ... ... | 6·8 |
| Width of ditto ... ... ... ... ... | 6·9 |

*Astragalus.*

| | |
|---|---|
| Extreme length ... ... ... ... ... ... | 2·3 |
| Width across tibial trochlea ... ... ... ... ... | 1·1 |
| Ditto distal extremity ... ... ... .. ... | 1·3 |
| Width of cuboidal articular facet ... ... ... ... ... | 0·64 |
| Ditto navicular ditto ... ... ... ... ... | 0·66 |
| Length of calcaneal trochlea ... ... ... ... ... | 1·3 |
| Width of ditto ... ... ... ... ... ... | 0·7 |

I have not had an opportunity of comparing any other of the limb bones of *Hyopotamus* with those of *Merycopotamus*, but the figures of the bones of the foot of the former genus seem to be very like the corresponding bones of *Merycopotamus.*

The above resemblances serve to shew that *Merycopotamus* must be a survivor of a very ancient type of structure; and also shew that the genus has affinities on the one hand as shewn by teeth and limb bones with the *Hyopotamidæ,* and on the other, as shewn by its skull and lower jaw, with the *Hippopotamidæ.*

PARASUCHIAN CROCODILE.

Mr. Hughes has lately sent in a specimen of a scute of a Crocodilian from the Dénwa group of the Mahadeva series, collected by him on the banks of the Dénwa river. The specimen is of importance, as hitherto no fossils have been obtained from these beds. I hope on a subsequent occasion to give a figure of this scute, and therefore at present shall only roughly describe it. The specimen is of large size, being at the centre more than an inch in thickness; it seems to have belonged to the dorsal series of scutes, and is from the right side; it is fractured through its centre, the longitudinal ridge being broken away; externally, it is convex from side to side; the inner border presents a flat surface for sutural union with its fellow of the opposite side; the posterior border is bevelled away inferiorly and overlapped the anterior border of the succeeding scute; a great part of the anterior moiety has been broken away. The upper surface is deeply pitted, and the peripheral pits are expanded into elongated grooves presenting a radiating arrangement. The specimen when complete was probably as large as broad, and indicated an animal of gigantic dimensions; the length of the one complete (inner) border is 6·1 inches. The above-mentioned characters shew that the specimen belonged to the Amphicœlian Crocodilia so characteristic of the mesozoic period. (See Huxley, Q. J. G. S., Vol. XV, p. 446.) At the anterior border of the specimen there is a smooth hollow on the inferior surface, which may possibly have received the extremity of a long peg from the anterior scute. A similar arrangement occurs in the scutes of *Goniopholis crassideus* of the English Purbeck; but in that genus the peripheral pits are not elongated as in our specimen, and have consequently no radiate arrangement.

The form of the pits and the articulations of the two remaining lateral surfaces agree very closely with those of the dorsal scutes of *Belodon* from the upper Keuper and Rhætic of Würtemburg,* and the arrangement of the pitting also agrees very closely with that which covers the scutes of the allied Indian genus *Parasuchus*, from the Kota-Maléri beds. The present specimen is, however, of very much larger size than any specimens of the scutes of that genus from those beds, although we have vertebra in the Indian Museum from those same beds which belonged to an individual which might not have been very much smaller than that to which the Denwá scute belonged. I think we may safely say that the above scute belonged to the group of Crocodilia Parasuchia, and very probably to the genus *Parasuchus*, but that the species was probably distinct from the Kota-Maléri species.

We have, in the Indian Museum, from a third distinct locality, an amphicœlous vertebra of a crocodile from the Chari beds of Kach, which is considerably like those from the Kota-Maléri beds.

This vertebra has an elongated and laterally compressed centrum, somewhat expanded at the ends; the articular surfaces are vertically elliptical and hollowed; there are large transverse processes, and a well-developed neural spine; the zygapophyses are concealed by matrix. The neurocentral suture is clearly marked and is placed considerably below the transverse process, the latter consequently rising entirely from the arch; this shews that the vertebra belonged to the posterior dorsal series, the rib not articulating with the centrum. The vertebra could only belong to the *Crocodilia Amphicœlia* or the *Plesiosauria;* the dorsal vertebræ of the latter order are, however, cylindrical and generally shorter than the present specimen, the proportion of the long diameter to the transverse diameter being in the Macrospondylian Plesiosauri never more than in the proportion of 10 to 8, while in the present specimen these two diameters are in the proportion of more than 2 to 1. A similar proportion prevails in the vertebræ of many of the Amphicælian crocodiles, to which group our specimen must belong. The dimensions of the specimen are—

| | Inches. |
|---|---|
| Length ... ... ... ... .. ... ... | 3·1 |
| Breadth of centrum (transverse) ... ... ... ... ... | 1·4 |
| Height of centrum ... ... ... ... ... ... | 1·65 |

The specimen has already been referred to by Dr. Feistmantel† as belonging to the genus *Parasuchus*. I am not, however, quite sure whether this is the case, but I think it is almost certain that the vertebra in question belonged to the *Crocodilia Parasuchia* and quite possibly to *Parasuchus;* it will require the discovery of scutes in the Chari beds to be quite sure as to the generic position of the vertebra.

If the specimen belongs to *Parasuchus*, it tends somewhat to approximate the horizons of the Chari and Kota-Maléri beds; the former beds have been considered as the equivalents of the Oxfordian and Callovian of Europe; but Dr. Feistmantel has indicated the existence of Liassic forms in these beds, which tend to place them on a somewhat lower horizon than the

* *Von Meyer Palæontographica,* Vol. VII, Pl. 43.

† Rec. Geol. Surv., India. Vol. IX, p. 16.

Oxfordian. In any case, however, the Chari beds must be considered newer than the Trias and the Rhætic, and the occurrence of a (probably) Parasuchian Crocodile in these beds somewhat does away with the value of that group as characteristic of the Trias or Rhætic.

I may here mention that the occurrence of the remains of a fresh-water Crocodile in the marine Chari group is paralleled by the occurrence of the estuarine *Teleosauri* in the marine Lias of Whitby; its presence serves to indicate that the Chari beds were deposited in a sea not far removed from the estuary of some large river.

Having now defined the affinities of our Denwa scute, and noticed the position of other allied forms in the Indian rock-series, we may turn our attention to consider whether it affords us any assistance in fixing the homotaxis of the rocks in which it occurs, during which we shall be led also to consider the age of the Kota-Maléri beds. From the great similarity of structure between the Denwa scute and the scutes of *Parasuchus* from the Kota-Maléri group, with the scutes of the European genus *Belodon*, I am inclined to think that the horizons in which these three forms occur cannot be very far removed in time; and, therefore, that the period of deposition of the two Indian groups must be somewhere near that of the upper Trias or Rhætic of Europe in which *Belodon* occurs.

We may here consider somewhat more closely the range in time of the vertebrates of the Kota-Maléri group; firstly, we find that the group of *Crocodilia Amphicœlia*, which embraces the minor division of the Parasuchia, ranges in Europe from the upper Trias to the Chalk, and is therefore characteristic of the greater part of the Mesozoic period; the smaller divisions of Parasuchia, which in Europe includes the two genera *Belodon* and *Stagonolepis* according to Professor Huxley,* is in that region confined to the Trias. Dr. Feistmantel, however, tells me that some of the beds in which *Belodon* occurs are now classed as Rhætic.

In addition to *Parasuchus*, the Kota-Maléri beds have also yielded remains of *Hyperodapedon*, which seems probably to belong to the Rhynocephala, and which in Europe is confined to the Triassic period. From the same deposits we also have three genera of fish—*Ceratodus*, *Lepidotus*, and *Æchmodus*; the first of these three is represented by the greatest number of species in the Trias of Europe, and is not known before that period; it is, however, found again in the Oolites of Stonesfield, and a solitary surviving species still lingers on in some of the rivers of Queensland. The genus *Lepidotus* in Europe ranges from the Lias to the lower Chalk, but is most common in the former period; the species described by Sir Phillip Egerton from the Kota beds of Hyderabad in the Journal of the Geological Society for 1851 is said to be most nearly allied to the oldest English forms; the genus undoubtedly belongs to a primitive type of fish; the genus *Æchmodus* in Europe is exclusively Liassic.

The following table represents the distribution of the above-mentioned genera:—

| | | Europe. | | | | | India. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Trias. | Rhæt. | Lias. | Oolite. | Cret. | Kota. | Denwa. | Chari. |
| Parasuchia | Belodon | × | × | ... | ... | ... | ... | ... | ... |
| | Parasuchus | ... | ... | ... | ... | .. | × | × | × ? |
| | Stagonolepis | × | ... | ... | ... | .. | ... | ... | ... |
| Rhynocephala | Hyperodapedon | × | ... | ... | ... | ... | × | ... | ... |
| Pisces | Ceratodus | × | ... | ... | × | (living) | × | ... | ... |
| | Lepidotus | ... | ... | × | × | × | × | ... | ... |
| | Æchmodus | ... | ... | × | ... | ... | × | ... | ... |

* Quar. Jour. Geol. Soc., 1875, p. 49.

The above table indicates a somewhat long period of time to which to refer the Kota-Maléri and Denwa beds; but I think we are justified in saying that they are not homotaxically older than the upper Trias or newer than the lower or middle Lias of Europe, and that they might, with a fair show of probability, be referred to the Rhætic period, or somewhere very close to that period.

The whole of the vertebrates from the Denwa and Kota-Maléri groups, as well as those from the older Panchet group, were inhabitants either of fresh water or of the land, and therefore indicate either a fluviatile or sub-äerial origin for the groups of rocks in which their remains are embedded.

The following remarks as to how the above determination agrees with the assigned position of the Denwa and Kota-Maléri beds have been kindly added by Mr. Medlicott:—

The Denwa fossil is a very timely find;—directly, as the first fossil from an immense thickness of strata; and indirectly, because, so far as it is identifiable with others from outlying localities, it supplies the all-important test of stratigraphical position, occurring as it does in the fullest continuous section of the Gondwana deposits. In this way it already furnishes a confirmation of the horizon, as very recently determined by Dr. Feistmantel, for the Kota-Maléri beds, and also for his judgment upon the relations of the Jabalpur and Rajmahal groups.

From a fair amount of evidence, Dr. Feistmantel has insisted on the close correspondence between the flora of the Umia zone (the top of the Jurassic series of Kach) and that of the Jabalpur group (the top of the Gondwana series in Central India), both having a strong Bathonien facies. The Rajmahal group he placed lower, the flora having Liassic affinities. The Kota-Maléri beds have hitherto been taken to be on the Panchet horizon, and therefore lower Gondwana. A few plant fossils were lately found in those localities; those from the bone beds were Jabalpur species; and in the underlying beds a Rajmahal plant occurred. The stratigraphical separation not being very decided, the group may be taken as representing the Rajmahal and an overlying zone. From Mr. Lydekker's estimate it would seem that the vertebrate remains are of a somewhat older type than that of the flora.

In the continuous section of the Satpura basin, the Denwa beds occupy an upper-middle position in the great thickness of the upper Gondwana strata, hitherto vaguely spoken of as the Mahadeva series,* between the Jabalpur group and the Bijori beds, which have been sufficiently identified with the Kamthi-Raniganj horizon of the lower Gondwanas in other areas. Several hundred feet of strata, known as the Bagra beds, occur between the Denwa and the Jabalpur beds; and below the Denwa group occurs the great Pachmari sandstone, the base of which has been conjectured as the probable horizon of the Panchets. In this standard section, then, the Denwa fossil confirms in a very satisfactory manner the position independently assigned from the flora for the Kota-Maléri group. If we could venture to press closely such slight evidence, we might conjecture that the Rajmahal group will have to take its equivalent out of the great Pachmari sandstone.

In his independent classification from examination in the field, Mr. Hughes places the Kota-Maléri beds low in the upper Gondwana series; well below the Balanpur coal, which very closely represents the coal in the Jabalpur group of the Satpura region.

If the fossil which Mr. Lydekker doubtfully identifies as *Parasuchian* from Kach should prove to be such, and thus a connecting link with the Kota-Maléri and Denwa horizon, we should have made an important step in extending the parallel between the marine Jurassic series of Kach and the Gondwana series; for that fossil also occurs well below the Umia-Jabalpur horizon, in the Chari on the Katrol group of Dr. Stoliczka's classification.

* Mem. Geol. Survey, Vol. X.

TITANOSAURUS INDICUS, n. gen. nobis.

I have formed the above new genus of *Dinosauria** upon the evidence of a large femur, and two large posterior caudal vertebræ, which are in the Indian Museum, and which were obtained from the Lameta group of rocks. The femur was collected by Mr. Medlicott in the year 1871 from the Lametas of Jabalpur; the vertebræ were also obtained from Jabalpur, and are shortly described in Falconer's "Palæontological Memoirs" (vol. 1, p. 418); the larger of the two is figured on a small scale in Plate 34 of the same work. No reference was, however, made to their affinities or even as to their position in the vertebral series.

I will first extract Dr. Falconer's description of these vertebræ, then compare them with the vertebræ of the other Dinosauria to which they are allied, and finally describe Mr. Medlicott's specimen of the femur. Dr. Falconer states: "The larger vertebræ consists of a compressed body, very considerably compressed sideways, and contracted in diameter between the articular surfaces, both in the vertical and transverse direction. The anterior articulation is elliptical vertically in its outline, and the cup as deep as in the *Crocodilia*; the posterior articulating surface is of a corresponding reversed form, *i. e.*, very convex, flattened laterally, the greatest convexity being towards the middle or axis. The inferior surface of the body at either end bears immediately behind the rim of the cup in front, and in front of the ball behind a pair of surfaces for the articulation of a chevron bone, *i. e.*, each chevron has been articulated to two adjoining vertebræ.

"The spinous process, which is broken off (near the summit), is flattened and of considerable size near the base; it is given off from the body backwards at an angle of about 45°. Between it and the body there is a semicircular niche about 1·2 inches deep. From the anterior part or base of the spinous process two articular apophyses are given up, nearly horizontally, or inclined upwards at a small angle; and diverge, but the divergence is small. The articular surfaces are on the axial side.

"It would appear that the next anterior vertebræ passed its spinous process between these articular surfaces; but no marks of such articulation are seen in the spinous process of the vertebræ.

*Dimensions.*

| | Inches. |
|---|---|
| Extreme length of body ... ... ... ... ... | 5·4 |
| Height in middle to hollow between spinous and articulating apophyses ... | 4·9 |
| Height of anterior concave end ... ... ... ... ... | 3·4 |
| Width of ditto ... ... .. ... ... | 2·4 |
| Length of body from rim to base of ball ... ... ... ... | 4·1 |
| Height of base of ball behind ... ... ... ... ... | 3·4 |
| Transverse diameter of ditto ... ... ... ... ... | 2·3 |
| Height of body where constricted behind ... ... ... ... | 2·8 |
| Greatest constriction of ditto ... ... ... ... | 1·3 |
| Length of articular process ... ... ... ... ... | 2·2 |
| Ditto from base of spinous process to top of ditto ... ... ... | 4·0 |
| Length of lamina, right side ... ... ... ... ... | 1·8 |
| Vertical diameter of spinous process ... ... ... ... | 1·9 |
| Transverse diameter of ditto ... ... ... ... ... | 0·8 |

"Vertebral canal small and constricted, not a trace of a suture remaining.

"The other vertebra (unfigured) is shorter and less perfect. The spinous process is broken off at the base, and the articular processes, if any, are gone. The body is shorter and less constricted; there are the same ball and socket ends, but they are not so deep; there are also the two surfaces for chevron bones."

* The term *Dinosauria* is here used in a general sense, as comprehending both the *Ornithoscelida* and the *Sauroscelida* of Professor Huxley.

To the above description I would add that there are no transverse processes; that the neural arch is anchylosed to the anterior half of the upper borders of the centrum, the posterior half of the latter being free; that a longitudinal furrow traverses the hæmal aspect of the centrum; and that the prezygapophyses are cylindriform and project far forwards.

We will now inquire to what animal the vertebræ are likely to belong. Firstly, from the presence of surfaces for the attachment of chevron bones, from the small size of the neural canal, and from the absence of posterior zygapophyses, it is quite clear that the vertebræ belong to the caudal region; and secondly, from the absence of transverse processes, and from the comparatively small size of the neural spine and prezygapophyses, it is clear that they belong to the posterior half of the caudal region.

The only mammalia of large size which have chevron bones attached to the caudal vertebræ are the *Edentata* and the *Cetacea;* in the former order all the caudal vertebræ have transverse processes, and the centrum is short and cylindrical; in the latter the centrum is still shorter and more discoidal. It is therefore clear, independent of their geological position, that the bones do not belong to the mammalia.

Turning now to the reptiles, we find that in the *Crocodilia* and the *Lacertilia* the posterior caudal vertebræ, though procœlous, have a persistent neuro-central suture; the neural arch extends as far back as the centrum; there are both pre- and post-zygapophyses; there is generally a transverse process, and the chevron bones articulate with only one vertebra;—so that each vertebra has only one pair of facets on its hinder border for their articulation. Orders of reptiles such as the *Ichthyosauria*, *Plesiosauria*, *Chelonia*, *Dicynodontia*, etc., have vertebræ of totally different types, and require no comparison with our specimens.

If, however, we turn to the order *Dinosauria*, we find that here we do meet with vertebræ which agree very closely with our present specimens; if we compare the figure of a posterior* caudal vertebra of *Pelorosaurus*, figured on Plate 26 of the Philosophical Transactions for 1850, with Dr. Falconer's figure of the Jabalpur vertebra (the two figures being taken from opposite sides of the bones), we shall find a very great resemblance in many points of essential structure. Firstly, both vertebræ agree in being elongated, in the absence of any transverse process, in having a neural arch of considerable height, in carrying prezygapophyses, but no post-zygapophyses; in the former, being cylindriform and projecting in front of the centrum, and in having a small neural canal; moreover, in both, the neuro-central suture is completely obliterated, while the neural arch does not extend backwards beyond the middle of the centrum, the posterior half of the latter being quite free; both vertebræ likewise have the inferior border of the centrum arched.

Having now considered the points of resemblance, we must point out the differences between our Jabalpur vertebræ and those of *Pelorosaurus*. The most striking difference is that our vertebræ are markedly concave anteriorly and convex posteriorly, whereas those of *Pelorosaurus* are slightly concave anteriorly and nearly flat posteriorly; the latter are also approximately cylindrical, and carry facets for the chevron bones only on the hinder extremity. The caudal vertebræ of Iguanodon (Owen, Brit., Cræt. Rep., Pl. 37) resemble our specimens in carrying two pairs of facets for the chevrons; they differ, however, by being thicker, nearly cylindrical, and by the greater length of the neural arch in proportion to the length of the centrum. The caudal vertebræ of *Cetiosaurus*, figured by Professor Philips in his Geology of Oxford, are very like those of *Pelorosaurus;* but the pre-zygapophyses are not cylindrical and do not project so far forward as in *Pelorosaurus*. The caudal vertebræ

* This specimen is called by Dr. Mantel " median caudal; it is, as stated in Philips' Geology of Oxford (p. 266) really a posterior caudal.

of *Hylæosaurus* also resemble our Indian specimens in having two pairs of facets for the chevron bones, and in having a longitudinal furrow on the neural aspect of the centrum; their articular surfaces are, however, nearly flat, and their centra sub-cylindrical.

The above comparisons, I think, prove quite clearly that our Jabalpur vertebræ belonged to a Dinosaur, closely allied to *Pelorosaurus* of the English Wealden, and to *Cetiosaurus* of the Bath oolite, and also presenting points of affinities to *Hylæosaurus* and *Iguanodon* of the Wealden. The Indian Dinosaur, however, differed from all the above genera in having the caudal vertebræ distinctly "procœlous" and laterally compressed.* From the large size of the vertebræ, I propose for the new genus the name of *Titanosaurus* with the specific name of Indicus. The length of the posterior caudal vertebræ of *Cetiosaurus* varies from five and a half to six and a half inches, so that our Indian species must have been nearly as large as the English giant. The forms of the articular surfaces of the vertebræ are quite sufficient to distinguish the Indian genus from all other genera of Dinosaurs.

Turning now to the femur, we find that this bone is embedded in matrix, and only shews its anterior aspect; both the condyles and the head have been broken away, so that we are unable to estimate either the full length or breadth of the complete bone; our specimen is from the left side, and agrees precisely in form with the larger femur of *Cetiosaurus* figured in diagram 108 of Professor Philips' Geology of Oxford; like that specimen, the anterior surface of our specimen is nearly flat, the inner border markedly concave, with a slight swelling two-thirds up from the distal end, which represents the third trochanter, and with the outer border less concave. The length of the fragment remaining is 46 inches, the breadth taken obliquely at the upper end 13 inches, the breadth of the narrowest part 8·3 inches, and of the broken distal end 11·5 inches. The specimen must have been at least 55 inches in length when perfect; the largest femur of *Cetiosaurus* known is 64 inches in length. The femur of *Pelorosaurus* is like that of *Cetiosaurus*, but smaller; that of *Iguanodon* is distinguished by possessing a third trochanter; the femur of *Hylæosaurus* is, I believe, not known. The size of the femur, therefore, shews an animal somewhat smaller than the largest individuals of *Cetiosaurus*, which Professor Philips estimates to have attained a length of sixty or seventy feet.

Both the vertebræ and the femur having been found in the same locality, and from the same formation—both belonging to Dinosaurian reptiles of gigantic size, and both having affinities to the same group of Dinosaurs—it is a logical inference that both should be referred to the same animal; if the femur had been found alone, I should have referred it to the genus *Cetiosaurus*, but the vertebræ forbid this view.

Both *Cetiosaurus* and *Pelorosaurus* were reptiles of terrestrial habits, probably living in marshy or estuarine districts, and we may infer that Titanosaurus, probably, had much the same habits; its occurrence in the Lametas indicates that these beds, as has previously been suggested, are of fresh-water orgin, like the Wealden of England. The caudal vertebræ of Titanosaurus belong to what we are usually accustomed to consider a higher type of structure than those of any of its European kindred. We may hope at some future date to find other remains of this huge Saurian, which will throw further light on its affinities, and shew whether it differed in other essential points from its European congeners.

The Lameta group of rocks are supposed by Mr. Blanford and Mr. Medlicott to be connected with the middle cretaceous rocks of Bagh (see Rec. Geol. Survey, India, vol. V, p. 115). The occurrence in these rocks of a Saurian closely allied to *Pelorosaurus*, and

* The caudal vertebræ of *Macrurosaurus semnus* from the Chloritic marl of Cambridge, are procœlous and compressed; this genus is doubtfully referred to the Dinosauria.

in some respects to *Hylæosaurus* and *Iguanodon* of the Wealden period, suggests that the Lametá group is not far removed from the lower cretaceous period—a view which would agree with their generally accepted position in the geological series.

I have lately found in the Indian Museum a considerable series of caudal vertebræ of this genus, which were collected by Mr. W. T. Blanford in the Lametas of Písdúra; they are somewhat less compressed than the described specimen: and are accompanied by coprolites, and some portions of the carapace of a Chelonian. I shall hope subsequently to give figures of the more perfect specimens. The vertebræ and femur referred to by Mr. Hislop in the twentieth volume of the Journal of the Geological Society (p. 282) probably belong to this genus.

MEGALOSAURUS, sp.

the fourth volume of the "Memoirs of the Geological Survey of India" (p. 128), Mr. H. F. Blanford announced the occurrence of the remains of this genus in the Arrialur group of Trichinopoli (Upper Cretaceous); this announcement, however, does not seem to be generally known, as Professor Phillips in his "Geology of Oxford" (p. 196), in speaking of the distribution of *Megalosaurus*, makes no mention of its occurrence in India; for this reason I have introduced the genus here.

The specimen on which Mr. Blanford's determination was made is the greater portion of a (probably) lower tooth; this tooth is laterally compressed, the anterior border is convex and the posterior concave, both produced into trenchant edges and marked by fine serrations; the transverse section is somewhat pear-shaped, the broader portion being in front. The height of the portion of the tooth remaining is 1·8 inches; the antero-posterior diameter of the base ·91 inch, and the transverse diameter ·4 inch.

The tooth in form and size is almost identical with the teeth of *Megalosaurus Bucklandi* of the Stonesfield and Portland oolites, the only difference being that the posterior border of the Indian tooth is rather straighter than that of the English species.

In England the genus *Megalosaurus* ranges from the Lias to the Wealden, and is therefore chiefly characteristic of the Jurassic period. In India, as we said, it occurs in rocks, of which the marine mollusca fauna is homotaxically equivalent to that of the upper cretaceous rocks of Europe. This instance should make us extremely cautious in correlating the horizons of Indian and European rock-groups upon the sole evidence of land animals. As in many other instances in India, the land flora or fauna (exemplified in this case by *Megalosaurus*) of a group of rocks, indicates a lower homotaxis for the group than does the marine fauna. This anomaly is probably to be explained by the greater similarity of physical conditions, and the consequent greater facility for migration in the ocean than on the land (to say nothing of the insulation of parts of the latter), by which the organised products of the former would sooner arrive at a new station than those of the latter; the assumption in this case being that the wave of migration has travelled eastwards.

Further remains of the Indian form are required to establish its specific distinctness; the tooth will subsequently be figured.

PLESIOSAURUS INDICUS, n. sp. nobis.

I have already recorded* the occurrence of a species of the above genus from the Umia beds of Kach. On further examination, I now find that the specimen of the symphysis of a mandible, on the evidence of which the announcement was made, differs both in size and in the direction of the alveoli of the teeth from the mandible of *Plesiosaurus dilichodeirus* from the English Lias; it also differs, as far as I can make the com-

* Rec. Geol. Surv., India, Vol. IX, p. 154.

parison, from other described species of the genus; all the cretaceous and most of the oolitic species of English *Plesiosaurus*, however, are described from teeth or vertebræ only,* so that there is a possiblity of our species being identical with one or other of these forms. I have, however, thought it best to give the Indian form a distinct name, if only to mark the locality from which it was obtained, and I propose to call the species *P. indicus;* no more accurate definition, however, can be given than that published in the first notice. A species—*P. Australis*—has been described by Professor Owen from Australia, so that we now know that the genus had wide distribution in space as well as in time.

### PACHYGONIA INCURVA.—*Huxley.*

This species of Labyrinthodont was described by Professor Huxley(†) from the Panchet group of rocks upon the evidence of a portion of a mandible wanting the extremity of the dentary piece; the jaw is characterized by carrying a row of minute teeth, which in cross section are transversely elongated. Among some specimens more recently acquired from the same group of rocks, I have found a part of a symphysial end of a left ramus of the mandible and a detached tooth of a Labyrinthodont, which belong to this genus. The mandible carries on its outer border a row of small, transversely, elongated teeth, from the form of which, and from the resemblance of the sculpture on the outer surface of the jaw to the same part in the type-specimen, I have referred the new specimen to *Pachygonia.* At the anterior extremity of the specimen, and placed somewhat internally to the outer row of teeth, there is one large conical tooth, longitudinally striated, and bearing the same relation and proportion to the outer row of teeth as does the similarly situated tooth in the jaw of *Labyrinthodon pachygnathus*, figured by Professor Owen in his Odontography (Pl. 63, fig. 5). A section of an isolated large tooth, which agrees precisely in form with the attached specimen, shews that the arrangement of the folds of the cement and dentine is almost precisely similar to those in the tooth of *Labyrinthodon* (*Mastodonsaurus*) *jaegeri*, as figured in Plate 64 A of Professor Owen's Odontography. I am not acquainted with the structure of the teeth of all other Labyrionthodonts, but those of two at least of the carboniferous genera (*Anthracosaurus* and *Archegosaurus*) differ very markedly from those of the Triassic type genus; in any case, the close resemblance in form of the symphysis of the jaw and of the structure of the tooth of *Pachygnathus* to the same parts in the jaw of the type genus *Labyrinthodon*, which is confined to the Keuper in Europe, affords a strong confirmation of Dr. Feistmantel's view, derived from the study of the flora, as to the homotaxis of the terrestrial forms of life of the Panchet group of rocks with those of the Keuper of Europe.

### DICYNODON ORIENTALIS.—*Huxley.*

In a recent paper in the Quarterly Journal of the Geological Society of London (Vol. XXII, p. 98.), Professor Owen expressed his opinion that the foramen in the humerus of *Dicynodon orientalis*, from the Panchet rocks, is probably homologous with the foramen of *Cynodraco major* described in that paper. The Professor was, however, unable to be positive in this assertion, owing to the imperfect specimens figured by Professor Huxley in his above-quoted memoir on the Panchet vertebratæ. From an examination of more perfect specimens now in the Indian Museum, I am enabled to state that the foramen in the

* British Cretaceous Reptiles, Owen,—Palæont. Soc. Phillips'Geology of Oxford.
† Palæontologia Indica, Ser. IV, Vol. I, p. 6.

humerus of *D. orientalis* is "entepicondylar," and consequently homologous with that of *Cynodraco* and not with that of the Lacertilia. On a future occasion I shall hope to give figures of these more perfect humeri, and also of other parts of the skeleton of *Dicynodon* and other vertebratæ from the Panchet rocks.

### MYLIOBATIS, Sp.

A specimen of a portion of the dental plates of a species of *Myliobatis* has been sent down by Mr. Wynne from the nummulitics of Kach; this is, I believe, the first recorded occurrence of the genus in Indian rocks. The specimen comprises the greater portion of four of the large median dental plates, and also shows on one side three small and diamond-shaped lateral plates; the small size of the innermost one of the three outer rows of dental plates, the two outer rows being absent, shows that the specimen belongs to the genus *Myliobatis*, and not to *Zygobatis*. The median teeth are rounded transversely, and somewhat hollowed near the middle line and along their outer border; their anterior border is concave. The antero-posterior diameter of these plates measures half an inch; the antero-posterior diameter of the external row of plates is also half an inch, and their transverse diameter three-tenths of an inch.

The plates are larger than those of any of the Bracklesham species of the genus, but most nearly resemble in form those of *M. Edwardsii*, from the middle eocene of that place. I think, however, that the Indian specimen will eventually turn out to belong to a distinct species.

The association of the remains of a species of *Myliobatis* with nummulites, and similar genera of Mollusca, in the eocenes of Bracklesham and Kach, is noteworthy, and serves to indicate that very similar conditions of climate must have prevailed in the two regions at the periods of the deposition of these strata. The genus is not known from strata older than the eocene, and is still represented at the present day.

## DESCRIPTION OF A NEW EMYDINE FROM THE UPPER TERTIARIES OF THE NORTHERN PUNJAB, BY W. THEOBALD, *Geological Survey of India.*

Throughout the vast series of beds superimposed on the nummulitic limestone in the Punjab, no remains are more common than fragments of different species of fresh-water turtle, belonging to the families *Emydinidæ* and *Trionychydæ*, though in too fragmentary a condition to be capable of more than generic recognition. During a late examination, however, of the upper Tertiaries south of Jhand, I have obtained two specimens, sufficiently preserved to afford a specific diagnosis.. Both specimens consist of the anterior portion of the shell of a fully adult and aged animal, and embrace the three anterior, vertebral and costal plates, comparatively little affected by crust, and one specimen displays (though not very clearly) the ventral surface as far as the inguinal opening: the oval plates being broken away. Both specimens correspond as regards the structure of their plates, the impressed lines marking which are very distinct, though the same amount of individual variation is seen as is met with in living examples of one species. I propose to briefly characterise it under the name of

BELLIA SIVALENSIS, n. sp.

*Testâ depressa quadrate ovata, margine simplici, carinâ vertebrali nullâ. Nuchali nullo vertebrali primo quinque-laterale antice obtuse angulate, lateribus concavis. Vertebrali secundo sex-laterali boleti-formi, antice et postice recto, lateribus antice rotundis, postice, valde concavis. Vertebrali tertio, secundo simili.—Costale primo, magno et medium quinti marginalis attingente. Gularium angulo valde acuto. Sutura pectorali cum post gularibus, fere recto.*

Shell oblong ovate, depressed, very flat along the vertebral region and without the trace of a keel, sides shelving, margins simple. Nuchal, none. First vertebral five-sided, with an obtuse angle in front. Anterior sides straight (26 mills), lateral concave (39 mills), base sinuated (26 mills), each vertebral being slightly notched posteriorly to receive a corresponding median prominence in the one following it. Second and third vertebrals equal and similar mushroom-shaped and six-sided. Front and base equal (27 mills). Anterior sides convex, posterior concave. The first costal large, reaching to the centre of the fifth marginal:—

| | Mills. |
|---|---|
| *1st* Vertebral; greatest width ... ... ... ... | 42 |
| " sides ... ... ... ... | 39 |
| " base ... ... ... ... | 26 |
| " long ... ... ... ... | 50 |
| *2nd and 3rd* Vertebral; greatest width ... ... ... | 50 |
| " base ... ... ... | 26 |
| " long ... ... ... | 39 |
| *1st* Costal; greatest diameter ... ... ... | 72 |
| " posterior side ... ... ... | 55 |
| Gular; broad ... ... ... ... .. | 22 |
| " long ... ... ... ... ... | 36 |
| Gular and post gular ... ... ... ... | 42 |

Marginals sub-equal, the first being the largest.

When perfect the shell must have been close on nine inches long and six broad.

The most obvious characters of this species are the great flatness of the top of the shell, the complete absence of any vertebral keel or nodosity, and the peculiar mushroom-shaped vertebrals. These plates very closely resemble *Bellia crassicollis*, Gray; a species which at present is not known to range north of Tenasserim, but that has a small nuchal plate which is certainly absent in the fossil. Still, however, the two are very similar, the fossil being rather larger than any living specimen of *B. crasicollis* that I have seen.

The geological horizon of the species is a very high one, the fossils having been obtained from a thick series of clays and sands overlying the great gray sandstone series with conglomerates (locally known on the Survey as the 'Dungote sandstones'), and which clays in fact constitute the highest beds of the Siwaliks in the Punjab. Associated with *Bellia sivalensis* are a great variety of fossils, among which it will suffice to specify *Colossochelys*, *Sivatherium*, *Equus sivalensis*, *Hippotherium*, and *Camelus*. These beds extend for some miles south of the great fault running east and west half a mile south of Jaba (a village 6 miles south-west from Jhand), either horizontal or with a slight northerly dip.

MALOWAL,
*22nd January* 1877.

W. THEOBALD.

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NOTE.—The above species of Emydine, according to Mr. Theobald's description, is quite distinct from any specimens in the Indian Museum; in this group of Tortoises I have already determined an *Emys*, an *Emyda*, a *Damonia*, and a *Bategur*, from the Siwaliks, in addition to *Pangshura tectum* determined by Falconer, which I shall subsequently describe.

It is somewhat noticeable that among the very few genera which Mr. Theobald has instanced as shewing the very modern age of the beds from which the new *Bellia* was obtained, that he has mentioned the genus *Hippotherium*, which in Europe is exclusively Miocene and older Pliocene.

R. LYDEKKER.

## OBSERVATIONS ON UNDERGROUND TEMPERATURE, BY H. B. MEDLICOTT, M.A., *Geological Survey of India.*

In 1875 two "protected Negretti" thermometers were sent to Dr. Oldham by Professor Everett, Secretary to the Underground Temperature Committee of the British Association. I happened at the time to be working in the Satpura coal-field, where the deepest borings for coal as yet attempted in India are in progress, so one thermometer was forwarded to me by parcel-post. To my great disappointment it arrived broken to atoms, in spite of its triple protection of glass, copper and wood, with cotton padding.* The occasion would not, however, have been propitious for observation, for a double reason: it was advanced in the hot season (March 1875), and it would have been difficult at any hour of the day or night to set the thermometer lower than the degree it would have to register in the hole; and also, the principal boring was in active progress, so that the heat generated by the work would have, to an unknown extent, falsified the ground-temperature.

In the following season (1875-76) I had to take up work in a distant part of India; but early this season (1876-77) I made arrangements to visit the borings at a favourable time. Some untoward circumstances occurred; but in one case, at least, the results are quite reliable, and therefore of interest. Observations were taken in three borings. They are all marked in the annexed table for comparison; but those at Manegaon only can be taken as satisfactory, for reasons that are explained.

Through the kindness of Mr. Wood-Mason I was supplied, in case of accident, with a Casella-Miller deep-sea thermometer (No. 18492). Both instruments were used together in each observation, the Casella above, the Negretti below, the bulbs being fifteen inches apart. The Negretti proved much the more sensitive and steady of the two, as may be seen from the table. There was on an average nearly half a degree index-error between them. All the readings are, of course, on the Fahrenheit scale. In every observation the line was worked very carefully by my own hand, or by my colleague Mr. Hughes. It was lowered very gradually to the required depth, and left at rest a full half hour at that depth.

All the holes are from five to six inches in diameter. At Khappa, the well above the piping, is 10 feet deep, the water standing just below the top of the tube. At Manegaon the well is 8 feet deep, the water standing at 11 feet from surface of ground.

* The protecting glass tube was unbroken, but the thermometer bulb was in fragments, and the stem broken in the middle, the cork disk having parted from the collar of the tube.

*Table of temperatures: 5th of December 1876.*

| Depth in feet. | Khappa. | | | | Manegaon. | | | | Moran. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Casella. | | Negretti. | | Casella. | | Negretti. | | Casella. | | Negretti. | |
| 10 | | | | 79°·2 | | 80°·8 | | 81·15 | | | | |
| | | | +1°·0 | | 0·0 | | −0·05 | | | | | |
| 20 | | 79°·8 | | 80·2 | | 80·8 | | 81·1 | | | | |
| | +0·7 | | +0·8 | | −0·3 | | −0·10 | | | | | |
| 40 | | 80·5 | | 81·0 | | 80·5 | | 81·0 | | 82·6 | | 82·1 |
| | +0·4 | | +0·5 | | 0·0 | | 0·0 | | −0·1 | | +0·9 | |
| 60 | | 80·9 | | 81·5 | | 80·5 | | 81·0 | | 82·5 | (c) | 83·0 |
| | +0·5 | | +0·2 | | +0·5 | | +0·3 | | +0·5 | | 0·0 | |
| 80 | | 81·4 | | 81·7 | | 81·0 | | 81·3 | | 83·0 | | 83·0 |
| | +0·1 | | +0·3 | | +0·2 | | +0·5 | | 0·0 | | +0·5 | |
| 100 | | 81·5 | | 82·0 | | 81·2 | | 81·8 | | 83·0 | | 83·5 |
| | +0·5 | | +0·15 | | +0·9 | | +0·9 | | +0·3 | | 0·0 | |
| 150 | | 82·0 | | 82·15 | | 82·1 | | 82·7 | | 83·3 | | 83·5 |
| | +1·2<br>−0·1 | | +1·45<br>+0·05 | | +0·65 | | +0·6 | | +0·7 | | +0·9 | |
| 200 | | 83·2<br>81·9 | | 83·6<br>82·2 | | 82·75 | | 83·3 | | 84·0 | | 84·4 |
| | −1·2<br>+0·2 | | −1·6<br>+0·2 | | +0·55 | | +0·7 | | +5·6 | | +5·45 | |
| 250 | | 81·6<br>82·1 | | 82·0<br>82·4 | | 83·3 | | 84·0 | | 89·6 | | 89·85 |
| | +2·0 | | +2·2 | | +0·9 | | +0·65 | | | | | |
| 300 | | 84·1 | | 84·6 | | 84·2 | | 84·65 | | | | |
| | +0·7 | | +0·55 | | | | +0·05 | | | | | |
| 350 | | 84·8 | | 85·15 | (b) | 84·3 | | 84·70 | | | | |
| | +0·2 | | +0·15 | | | | | | | | | |
| | (a) | 85·0 | | 85·3 | | | | | | | | |

*Moran bore-hole.*—These readings are only recorded to show the disturbing effects of the heat generated by the tools. The work was stopped only four hours before the observations were taken. The general conditions of the bore are very similar to those of the other two, but the increase of temperature is apparent throughout, and the rapid rise near the bottom is very marked. It would, no doubt, have been more so had the observation been taken quite at the bottom, which was still seven feet below the last reading recorded in the table.

(a) In mud at bottom at 370 feet.
(b) At 310 feet, in mud at bottom.
(c) A bump occurred against the end of the tube in raising.
*N. B.*—The Casella readings may be ignored.

*Khappa bore-hole.*—As the deepest boring of all, this was the one I was most anxious to observe in; and the failure is partly due to over-caution. At the close of last season (31st May) this hole had reached the depth of 633 feet. I had requested that it might be securely closed; and this was so effectually done that it took five hours battering with hammer and chisel to remove the wooden plug. These shocks must have vibrated through the tube, with which the hole is lined to a depth of 270 feet, and thus disturbed the partially unstable equilibrium in the column of water upon which the result of observations in these small-bore sinkings depends. It would seem even that something more than active convection was thus produced: after the thermometers had been down for fifteen minutes at the 200 feet position, a strong bubbling set up both within and around the tubing, and the water rose three or four inches. This occurred 13 hours after the tube had been opened. The reading then taken (the upper one of the table), at 11 p.m., showed an exceptional rise of temperature; and the next reading, at 250 feet, showed an equally exceptional fall of temperature. Both these points were observed again in the forenoon of the following day, with very different results (the lower readings of the table), and probably nearer to the normal state of the temperature. All the readings, however, about this depth (150′ to 250′), if compared with the corresponding readings in the Manegaon bore, and with the sudden rise in the reading at 300 feet, suggest a zone of slow percolation of surface waters. The necessity to introduce piping to the depth of 270 feet is probably connected with this water-pressure. Nothing was noticed in the samples of rock from these depths to suggest a local cause for such percolation. The sandstones and clays have the same average characters and alternating arrangement as throughout the boring. The reading at 300 feet in Khappa is probably a true earth-temperature. It agrees remarkably with the corresponding one at Manegaon.

Another disappointment connected with the Khappa bore-hole was, that it had filled up with mud to a depth of 260 feet. The observation at 370 feet was the lowest that could be taken.

The observations at Khappa were made on the evening of the 4th and morning of the 5th December. The air temperature was above 90° in the day; 75° at 5 p.m.; and 52° at 10 p.m.; 62° at 8 next morning; and 78° at 10 a.m.

*Manegaon bore-hole.*—Everything was favourable for satisfactory observations in this boring, except that the hole had silted up to a depth of 110 feet, its full depth having been 420 feet, while the lowest observation obtainable at the time of the observations was 310. It was closed on the 24th of April 1875; so that it had been at rest for 20 months. There is only one guide-pipe, ten feet long, at the top of the bore, there never having been any pressure of water in the hole. The position is low, and the water had always stood at or near the mouth of the tube. There was no difficulty in removing the plug.

The very equable series of temperatures is the natural result of these conditions. The observations were taken in the evening of the 5th and morning of the 6th of December. At 5 p.m., the air temperature was 72°; at 8 p.m., 59°; at 8 a.m., 65°; at 11 a.m. 84°.

The slight decrease of temperature in the top readings is a good proof of the perfectly tranquil conditions of observation. It is no doubt due to the excess of summer heat not yet abstracted; and it is apparent that that influence reaches to a considerable depth—quite to 60 feet. With a specially sensitive thermometer, the range of its variation might, no doubt, be determined with much accuracy in such a boring.

An idea of the climatal conditions may be obtained from the following abstract of observations at the two nearest meteorological stations, kindly furnished to me by Mr. H. F. Blanford. Khappa and Manegaon are two miles apart, and at about the same level, in an open valley of the Satpuras, traversed by the Dudhi river, south of the wide plains of the Narbada valley, about half-way between Jabalpur (Jubbulpore) and Hoshungabad, which are 150 miles apart. At these two places the temperature-conditions are as follows:—

*Monthly Mean Temperatures.*

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jubbulpore ... | 61·7 | 66·2 | 75·1 | 85·4 | 90·9 | 86·7 | 78·5 | 77·8 | 78·5 | 73·6 | 66·0 | 62·0 |
| Hoshungabad ... | 66·5 | 71·2 | 79·8 | 88·4 | 93·3 | 86·8 | 78·8 | 78·3 | 79·5 | 77·3 | 71·5 | 68·3 |

*Yearly.*

| | | |
|---|---|---|
| Jubbulpore ... ... ... ... | 75·2 ... ... ... | 1,351 feet above sea-level. |
| Hoshungabad ... ... ... ... | 78·3 ... ... ... | 1,020 „ „ |

*Extremes in 1875 in shade.*

| | | | | |
|---|---|---|---|---|
| Jubbulpore ... ... ... ... | Max. 111° | 7th June | Min. 34° | 3rd February. |
| Hoshungabad ... ... ... ... | „ 114° | 19th May | „ 40° | 22nd January. |

The elevation of Manegaon may be about 1,400 feet. The mean temperature, I should think, must be quite equal to that of Jabalpur. The extremes are certainly greater; in these more sheltered valleys a strong hoar-frost occurs many nights in January and February; and the heats of summer are also more concentrated. This mean surface temperature is still a very uncertain element of the ground temperature question here.

The geological conditions of the position are favourable for these observations. The rocks consist of steady alternations, in about equal proportions, of fine softish sandstones, and hard silty clays of the upper Gondwana strata having a steady dip of about 10°. The *raison d'être* of the borings is, of course, the conjecture that the coal-measures may be within reach below. There can scarcely be a doubt that they are present, but the depth cannot be estimated with any certainty. Strong trap dykes are frequent in many parts of the stratigraphical basin; but there are none within a considerable distance of these borings. There are no faults near, nor any rock-features having a known disturbing effect upon the heat-distribution.

If, then, we may for the present disregard the uncertain element of the mean temperature at the surface of the ground, and take the constant temperature of 81° at a depth of 60 feet, the readings below that point in the Manegaon bore give a very steady rate of increase of 1° Fahrenheit for every 66 feet of depth. The bottom reading in the Khappa boring may be taken as supporting this conclusion.

## DONATIONS TO THE MUSEUM.

(OCTOBER TO DECEMBER 1876.)

| | |
|---|---|
| Carbonate of Iron, largely mined at Brendon Hill, Somersetshire, for making Bessemer Steel ... ... | H. B. Medlicott, Esq. |
| Boulder of (?) auriferous quartz; from North Lakhimpur, Assam ... ... ... ... | Major L. Worthington Wilmer. |
| Slab of Coal shale with fossils from Kurhurbari ... ... | T. J. Whitty, Esq. |

## ACCESSIONS TO THE LIBRARY

FROM 1ST OCTOBER TO 31ST DECEMBER 1876.

*Donors.* *Titles of Books.*

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# RECORDS

OF THE

# GEOLOGICAL SURVEY OF INDIA.

**Part 2.]** 1877. **[May.**


## NOTE ON THE ROCKS OF THE LOWER GODÁVARI, *by* W. KING, A. B., F. G. S., *Geological Survey of India.*

In the Madras Presidency my work of last season was carried on in the Godávari District, the Nizam's Dominions adjacent to this, and thence northwards by Sironcha and Maleri, over which latter country Mr. Hughes and I made a joint survey of some unsettled features in its geology.

In the Godávari District, as far as it is included in Sheet 94, the survey of all the more important formations has been completed; while the area of the crystalline rocks, though not examined in much detail, has been ascertained, and the inland boundaries of the great alluvial deposits of the Delta and thence along the coasts have been laid down.

In addition to the regular survey of the country, I was occupied for some time in directing the coal-borings at Beddadanole, which were carried on until the end of May, when the works were stopped by the coming on of the monsoon. Some delay was caused by the loss of boring rods and the unsuitability of the tools for greater depths than 350 feet; but sufficient exploration had been made to lead me to the conclusion that it was not advisable to continue the trials any longer. The trial borings were made over about one-third of the area of the field, sixteen holes were put down, from 193 to 356 feet in depth, and six seams of carbonaceous clays, clays with films of mineral-charcoal, and coaly shale were passed through. None of the coaly material met with was of any use as a fuel; and there were no indications of improvement in the seams as they were tested in their extension. From the floor of the field, which was struck on its eastern edge, to the highest exposed beds as they crop out from under the Kámthis on the western edge, there was no improvement in the seams as to their depth in the field. The line of bore-holes across the strike lead me to conclude that more than 600 feet of Barákars were pierced. On the other hand, the country of Kámthis to the westward, overlying any possibly hidden seam in the upper part of the Barákars, rises too rapidly to allow of search in that direction to moderate depths with any hope of success. On these grounds I sent in my final report to the Madras Government, advising that the explorations should be discontinued; and the order thereon has since been issued intimating that it is not necessary to continue the borings; but that it may be worth while having a shaft sunk to see the material of the best seam in some quantity. I am, on this, directed to advise the Executive Engineer in charge as to the site of such shaft in case of its being decided to excavate it.

In my rapid and rather devious march northwards from the Godávari District to the Central Provinces I was enabled to trace, on the western or Hannamconda side of the country in the Nizam's Dominions, the connexion of the Godávari Gondwánas with their equivalents around Sironcha, Kota and Maleri; while some further extension of the coal-measures was found to be probable to the north of the Kamárum coal field near Pakhál.

Much of my time during the early part of the season was occupied in going over old ground in the Godávari District, examining the details of groups of rocks, so that the area of country surveyed is not large; but in the traverse to the north a tolerably fair knowledge was obtained of the general character and relations of the rocks of a new area extending over about 2,000 square miles, or 1,590 square miles in Sheet 74, and in the Hyderabad Sheet 400 square miles.

The succession of groups of rocks in the Godávari District (Sheet 94) remains the same as has been already pointed out in my previous notes; but some alterations as to the extent of these and a revision of their boundaries have become necessary in consequence of my having found last year that the patch of sandstones (Golapilly) north-north-west of Ellore is mostly of the Rájmehál group, and not, as was at first considered, of Kámthi age.

The groups which I would now finally put forward for the different series in this district, and tentatively for those in the parts of the Nizam's Dominions and Central Provinces lately examined, are as follows, in descending order :—

| | | Godávari District. (Sheet 94). | Nizam's Dominions. (Sheet 74). Pakhal, Modapur, Chinnur | Central Provinces. (Sheets 73 and 74.) Sironcha, &c. |
|---|---|---|---|---|
| | | Alluvium. | | |
| Tertiary ... | ... | *Rajahmandry sandstones (Cuddalore sandstone of H. F. Blanford).* | | |
| Secondary .. | Lameta | Kartairoo traps and intertrappeans. | | *eccan Trap.* |
| | | Pangady infratrappeans.* | | |
| Upper Gondwanas. | Jabalpur | Tripetty sandstones... | | Chikiala sandstones. |
| | | Ragavapuram shales | | Kota and Maleri beds. |
| | Rajmehál | Golapilly sandstones | Sironcha sandstones | Sironcha sandstones. |
| Lower Gondwanas. | Kámthi | Dummapett sandstones ... | Lingagoodium sandstones | ? Tarcherla sandstones (at Kaleswarum). |
| | | Chintalpoody sandstones | ? Tarcherla sandstones | |
| | | Barákars (Beddadanole and Badrachellum, &c.). | Barakars (Kamarum and Singareny). | Barakars (Nandpa, Chanda Sheet). |
| | | Talchirs (Badrachellum &c.). ... | Talchirs (Singareny, Kamarum, Gullady, &c). | Talchirs (Nandpa). |
| Vindhyans | | Kadapahs (western side of Sheet 94). | Kadapahs (Pakkal and Chinnur). | Kurnuls, (Nandpa, Kamana, &c. |
| Crystalline | | Gneiss (Garnetiferous) ... | Gneiss (Granitoid). | Kadapahs (Nandpa). |

## The Godávari District.

The Upper Gondwánas, consisting of Tripetty sandstones, Ragavapuram shales, and Golapilly sandstones, occur as a narrow belt of from 10 to 15 miles in width across the district in a west-south-west to east-north-east direction, from the neighbourhood of Ellore

* I think the fossils of the Pangady Infratrappeans (Lameta) show cretaceous affinities.—W K.

to near Tallapoody on the right bank of the Godávari, and thence by a few distant outliers of the upper group near Innaparazpolliam in that part of the Vizagapatam district included in this sheet of the Atlas.

The main belt rises up at a low angle (5° to 10°) from the western edge of the Godávari delta, or from under the Rajahmandry sandstones and the Deccan traps and infratrappeans of Pangady, and presents a low, sloping and scarped edge to the north-west, or towards the Chintalpoody country of Kámthis, which in its varied surface of hills and plains presents a marked contrast to the uniform surface of the series now under notice.

The grouping of the series is very clear in its main belt between the Godávari and the Ellore river (Tormalair). Uppermost, there is a thin (40 feet) set of dark-brown and red sandstones and conglomerates, essentially ferruginous, with silicio-argillaceous conglomerates and pebble-beds, and bands of concretionary clay-iron-stones. These are rather softer and more varied in colour towards the bottom, becoming harder and more ferruginous as they are traced upwards, and the upper beds are the heavy ferruginous conglomerates and lateritoid patches which make up the Yernagoodem and Yadavole country sloping down to the Delta. On a conspicuous point of the north-west scarp is the well-known Pagoda of Chinna Tripetty, whence the name of the group.

The Tripetty beds, in the main area, have as yet only yielded a few indistinct fragments of fossil wood; but from the Innaparazpolliam outliers, which I consider to belong to this group, a small collection of fossils was obtained, from which Dr. Stoliczka inferred that the rocks must be of uppermost jurassic age, because the fossils are allied to those of his Umia beds in the Kachh series.

Below the Tripetty scarp and near Ragavapuram, these sandstones are seen to pass down by softer and less sandy beds into a set of white and buff shales, having a few beds of sandstone near the bottom. Near Ragavapuram, in the slope of an outlying plateau, numerous fossils occur in these shales, among which a *Leda* is the most common form, ranging through all the beds, and with this are associated fewer specimens of *Pecten, Gervillia, &c.*, and a few cycloid fish-scales. About one-third way up the group are some thin yellow and brown flaggy and shaly sandstones, in which specimens of an Ammonite are frequent, with many fragments of *Ptilophyllum* (*Palæozamia*) and a few other plant remains.

The shales form a lenticular patch between the upper and lower sandstones of about twenty miles in length along the scarped edge of the series, being well overlapped at each end by the Tripetty sands, which then rest on the bottom group. Near Talapoody, and as outliers near Innaparazpolliam, the Tripetty beds overlap the lower sandstones and rest directly on gneiss.

The Ragavapuram beds are very like the Rájmehál shales of the Trichinopoly and Nellore Districts; and they resemble, except in being less hard and porcellanic, the fossiliferous shales found last season by Mr. Foote in the Nellore and Kistnah Districts, which contain, I believe, some plants and molusca similar to those of Ragavapuram.

Below the shales comes another set of brown and red sandstones and conglomerates, which, in the main area, have not yet yielded any fossil remains except indistinct fragments of stems. At either end of the belt, these rest on the gneiss, though for the rest of their extent they rest unconformably on the Kámthis or Chintalpoody sandstones; and at one or two points near Kanlacheroo they form small cappings to isolated hills of the same series.

At the Tripetty end of the belt, this lower member is rather thin, and is especially marked by a very heavy dark-brown ferruginous conglomerate, and a strong conglomerate of clear quartz pebbles in a chocolate-brown silicious clay-stone (rather jaspery in appearance) or very hard compact sandy clay-stone.

At the Ellore river, the main band of Upper Gondwánas is separated from a more western area of plateau and scarped sandstones by an interval of alluvium. These constitute the Golapilly country, and it was from the low plateau to the west of Golapilly, near the village of Ravacherla, that I obtained the series of plant remains which led Dr. Feistmantel to consider these sandstones as of Rájmehál age.

This finding of the fossils at once confirmed me in my ideas as to the Golapilly area being an extension of the Tripetty beds and subjacent sandstones; and I was finally led to consider these latter as representing the lower group of sandstones, but considerably thickened out. At the same time, the Golapilly plateaus are, I think, composed in their upper beds of Tripetty sandstones, while the capping of the higher parts, as Doodoogut hill, are of the Rajahmandry sandstones. It is in these higher conglomerates and pebble beds that the old diamond mines or pits are excavated near Mulaily and Golapilly.

Mr. Blanford found, and I have since seen myself, remains of *Glossopteris* and *Vertebraria* at the extreme northern edge of the Golapilly and Nuzaweed area of sandstones near the village of Somavarum; and this naturally led him, in addition to the general lithological characters, to consider the whole area as of Kámthi age. The plateau-form of the low hills even in the Somavarum parts of the area is, however, so constant, and the lithological resemblance between the conglomerates to the south-west of the village and those in the sandstones underlying the Ragavapuram shales is so strong, that I was obliged to look on this area as all of Upper Gondwánas, the *Glossopteris* and *Vertebraria* beds close to Somavarum being merely a remnant of the Kámthis, whilst there is no evidence of unconformity afforded by any striking change in the lie of the beds.

Certainly, between Somavarum and the north-west base of the Doodoogut plateau, the strata are generally unlike Kámthi beds. They are rather fine-grained, thin-bedded and platy *micaceous* sandstones; and these lie on a heavy conglomerate (ferruginous) such as may often be seen in both Upper and Lower Gondwánas, though it struck me that here it is most like the jaspideous conglomerates in the group below the Ragavapuram shales.

As already stated, the wide outcrop of the Upper Gondwána beds with the gentle slope from the north-west, and the plateau-like character of the outlying hills, more especially in the Gollapilly and Sonavarum country, are wonderfully characteristic in contrast to the Chintalpoody country of Kámthis; but a further reason for my thus limiting the area of the Upper Gondwánas is the fact of their gneiss-floor being such as to have aided in giving them their flat lie, and that its evenness of surface does not extend under the Kámthis.

At the Golapilly end of the country, also near Talapoody on the Godávari, and thence east-north-eastward, the crystallines rise from the alluvium in long slopes, remarkably like those of the sandstones, and form plateau-like hills which are escarped to the north-west. Beyond these are further groups of hills and ridges, nearly all of which are more or less flat-topped, their upper surfaces having also a gentle rise to the north-west, until they reach their highest level (about 2,000 feet) in the Papaconda or Bison hill-range, through which the Godávari has cut its great gorge. The same features are likewise seen very clearly in the numerous hills between Golapilly and Bezwada] in the south-west corner of the sheet; and the obvious conclusion is that these flat, elevated areas are really the remains of an old marine floor on which the upper sandstones were deposited.

Near Innaparazpolliam the fossiliferous sandstones are lying or shoring up on the first slopes of this even floor of gneiss. The same sandstones, and also those of the lower group, are shoring up over the denuded gneiss of Talapoody; and this shelving character is clearly evident at Golapilly.

On the other hand, the Kámthis of Chintalpoody, &c., are not lying on any north-west extension of this marine plateau, but are at a generally lower level, and on what must be a much more uneven floor which may, it is true, have been cut out of the old marine plateau, or may even have existed, with its Lower Gondwánas on it, before the Upper Gondwána floor had been pared down.

On the last point, as to the post-Kámthi formation of this floor, there is some evidence in the even strike of the Upper Gondwánas right across the Kámthi area. But this, with the kindred questions as to the direction of the slope of the old Kámthi valley, and the possibly much later age of the present Godávari valley, must be left for future consideration.

## LOWER GONDWÁNAS.

No further examination was made of the Kámthis during this season, except in a general way while working along the north-west edge of the Golapilly group, or in crossing to and from the Beddadanole basin of Barákars.

It seemed to me, all through my work, that there may be good reasons for the eventual distinction of the sandstones of Chintalpoody and its neighbourhood, from a higher group to the north represented by very coarse, softish, white, purple and grey sandstones in the plateau hills around Dummapett in the Nizam's Dominions, to the west of Asharaopett. The Chintalpoody group is characterised by rather less coarse beds of more varied colors of red, brown and purple, while they are generally more ferruginous than those of Dummapett. There are also rather marked sets of beds full of nests and lumps of white, yellow and red indurated clay or hard (non-laminated) shale, these being not so much foreign fragments in the sandstone as irregular seams and segregations of clay, for there are often fair laminæ and even thin beds of the same material interstratified with the sands. It was in one of these seams of rather calcareous clay-stone near Kunlacheroo that Mr. Blanford found *Glossopteris* and *Vertebraria;* and I obtained more of these plant remains from another outcrop of the same kind of clays a few miles further to the south.

The Barákars of Beddadanole crop out to the eastward from underneath the variegated ferruginous beds of the Chintalpoody group, and though I am much inclined to suspect that there is unconformity between them as well as overlap, there is no clear section showing this. The association of the Barákars with the Asharaopett Kámthis is the same as I have seen it at Kamarum and Singareny: there is in each case a small patch of the former very clearly overlapped by the latter; and there certainly seemed to me to be a slight difference in the strike and inclination of the strata at certain points, though this after all is what might be expected to occur in beds of such varying thickness and extent as those of the Barákars in the Godávari area.

NIZAM'S DOMINIONS AND CENTRAL PROVINCES.

In marching to join Mr. Hughes in the Sironcha country, I came upon the northerly extension of the Kámthis beyond Pakhál Lake (east of Hannamkonda), to which part of the country I had carried their western boundary in a previous season.

This afforded me an opportunity of again visiting the Kamarum coal-measures, when also the Tálchirs, which I had considered at the time of my first visit to be partly of volcanic origin, were re-examined. In this view I was much mistaken, there being after all only a strong resemblance to volcanic rocks in the peculiarly weathered black and dark-green sandstones, and the quasi-vesicular character of some of these.

To the east of Kamarum, the western edge of the Kámthis is seen very plainly in the hill ridges of Lingagoodium,* which range north-north-west to the Sullavey cross-valley; and beyond is a further group of hills to all appearance of the same series.

In the long valley of Kottapilly, below the Lingagoodium range, traces of Tálchirs are seen, but these could not be traced into contact with the Kámthis, owing to the extensive covering of superficial deposits. Further north, near Sullavey, the Talchirs are again met with in some force, lying, on their western edge, on Vindhyan quartzites and clay-slates, but overlaid by salmon-colored mottled sandstones on the Sullavey side.

The rocks which I have here called Vindhyans are in every way similar to those of the Kadapah series, namely, quartzites (sands and conglomerates) and coarse clay-slates, with occasional thinner bands of grey and bluish-grey splintery silicious limestones weathering brown. These stretch northwards from the Pakhál Lake (which is on the Vindhyans) as a band of some ten miles in width between the Kámthis of Sullavey, &c., and the gneiss of Hannamconda and the country northwards.

I think there is every reason to consider that the Lingagoodium beds extend as far as the groups of hills around Sullavey, that is, from their general appearance and lie; but there is room for doubt as to whether the sandstones in the lower lying country to the north are of the same age. My attention was drawn more particularly to this in my traverse from south to north from Hannamconda to Chinnur near Sironcha. To the eastward of this line the country is marked by many groups of rather high hills, generally presenting their steeper sides to the west and north-west, their strata having a dip to the east and south-east. These hills are all, I feel sure, of the typical brown sandstones of the Kámthis; but unless there be great faulting, of which there did not appear to be any sign, there is a great series of lower sandstones hading out from under the hill strata, and spreading over all the country west of Madapur up to the reach of the Godávari above Sironcha.

These sandstones are generally not so brown and ferruginous, or so hard, as the general run of Kámthis, and among them are soft yellow and reddish-brown beds of very fine texture: neither are they so harsh to the touch. Chocolate and salmon colors are common in the lower strata. A special variety is a rather fine-grained soft sandstone of salmon-red color, containing numerous fragments of pale-red and purple shales and calcareous shales scattered through the rock or, as often, in thin seams of smaller fragments. These contained fragments would appear to be from the Pem shales noticed by Mr. Blanford.

Near Sullavey, the Tálchirs are overlaid by sandstones remarkably like these mottled beds.

* Lingagoodium is 15 miles east of Pakhal Lake, which is 20 miles east of Warungal.

Looking at the physical aspect of the country, and seeing that the general north-west—south-east strike of the Kámthi strata is still maintained among these doubtful sandstones up to and beyond the Godávari, while the dip is also to the eastward, the natural conclusion is that these are lower beds than those of Pakhál and the Godávari District, or that they are of an older group, say the Barákars. They certainly did not strike me as having a Barákar look, though there are occasionally near the bottom of the series thick beds of coarse, soft, light-colored sandstones which might be of this group; but their apparent position with regard to the strata of the Sullavey hills and their lying on the Tálchir patch at that village are worthy of consideration on this view of their possible age. Still, until the country is more closely examined, the preferable conclusion is that they are really part of the Kámthi series and inferior to the strata of Lingagoodium, &c.

It must, however, be mentioned that when Mr. Hughes joined me, he had already been working for some time at these beds between the Malnair and Godávari rivers, west of Sironcha, and was rather under the impression that they belonged to a later series than the Kámthis. If this be the case, they must then have been deposited round the Sullavey hills over the base of the Kámthis and on to the outlier of Tálchirs. To distinguish them as a group, we adopted the name Tarcherla sandstones, from a village on the Malnair river.

At the junction of the Pranhita with the Godávari, just north of the village of Kaleswarum, these Tarcherla beds are overlaid by further strata having very much the same dip, though they differ somewhat in their constitution. There is, however, a local unconformity on the Kaleswarum bank, which, though only small, was sufficient to draw our attention to the possibility of its being more general among the rocks, and that we were here at the bottom beds of a newer series. A bed of fine-grained sandstone with a rather undulating dip to north-north-east at about 5° overlies the partings between five other beds of coarse pebbly sandstone which have a north-east dip of about 10°. This exposure being only about 20 feet in length, and in sandstones which are not constant in the thickness of their strata, it is possible that the unconformity may only be local and a case of oblique bedding, though from the fact of our almost immediately coming on Rájmehál strata above, it is most likely a true break.

At any rate, after crossing the river, and on the right bank of the Pranhita opposite Sironcha, we came on sandstones which differ in many points from those of the country to the south and north-west. They are *micaceous*, thick and thin-bedded, harsh, even-textured grey and brown sandstones, but they at the same time contain fragments of buff and pink shales. These are succeeded, as the short section opposite Sironcha is followed out, by thinner and conglomeratic beds, and these again by some of the thick beds with contained lumps of shale. Above these again is a set of finer grained buff, grey, purple and yellow soft laminated sandstones, rather shaly and flaggy, containing fragmentary plant remains said to be of a Rájmehál type. All the beds are micaceous, and in this differ from the Kámthis. The river section is then covered up by alluvium, and nothing more is seen until a couple of miles south of Anarum, where there is a low rise of friable pebbly sandstones having a flat and undulating lie, and at the village, associated with these sandstones, are grey and purple shaly bands containing plant remains, the only recognizable form being a *Palissya.*

Irrespective of the finding of these fossils, we were quite satisfied of the series (with the exception of the beds containing fragments of shales) being different in character and appearance from the Tarcherla sandstones. At the same time, they do not resemble the Upper Gondwánas of the Godávari District, except in the presence of mica, which mineral is frequent in the Golapilly group of sandstones.

Opposite Anarum at Kota, there is an outcrop of 9 feet of hard, sometimes rough-grained, grey or fawn-colored, splintery limestone with fish remains (bones, teeth, scales, &c.), some of the beds showing very indistinct ***Estheriæ***. These limestones are not seen associated with any other beds; but they dip east-north-east, at 10° to 12°, undulating slightly, and it is quite evident from their position that they overlie (with some intervening deposits) the ***Palissya*** beds of Anarum, and are succeeded by red clays and variegated sandstones a short distance higher up the river bank.

The Kota limestones appear again at Katarapilli higher up the Pranhita, where they crop up to the west-south-west at the usual angle, and must overlie the red clays of Maleri; and, about twenty-four miles still further to the north-west near Bimpur, the Maleri clays are overlaid in situ by limestones of the same kind, with the usual fish remains. Clearly, these limestones are a thick intercalation in the red clays and sands, though the proper fossiliferous clays of Maleri itself, with Ceratodus teeth, crocodilian bones and coprolites are underneath them, while there are variegated sands and red clays above them in the river section at Kota.

About eight miles to the north of Kota, on the left bank of the Pranhita, there is a high scarped plateau-range of hills overlooking the village of Chikiala, the strata of which are newer than those just described; and these must, I think, be considered at present as answering to the Tripetty sandstones of the Godavari District.

The upper red clays of the Sironcha series are visible in the river near Chikiala, but above these no rocks are seen until well up the slopes of the plateau, and then, brown and red ferruginous sandstones and conglomerates appear in great force and so continue to the summit of the plateau. The resemblance between these beds and those of the Tripetty scarps is remarkable; and there are just the same vitreous ferruginous conglomerates, hard silicious and argillaceous conglomerates, and bands of concretionary clay ironstones, as occur in the Godávari and Ellore country. The series seems, however, to be very thick in the Chikiala plateau, and fully the lower half of the slopes is concealed by debris. I did not see any indications of shales like those of Ragavapuram. The Chikiala scarps appeared to be continued away eastward into the Bastar country by still further ranges of flat-topped hills.

Thus, for the Sironcha country, as far as our rapid examination can show, the Upper Gondwánas are represented by the—

*a*. Chikiala sandstones.
*b*. Maleri red clays and Kota limestones, and the
*c*. Sironcha sandstones,

which answer by their fossils in the one case, and the wonderful lithological resemblance in the other, to the—

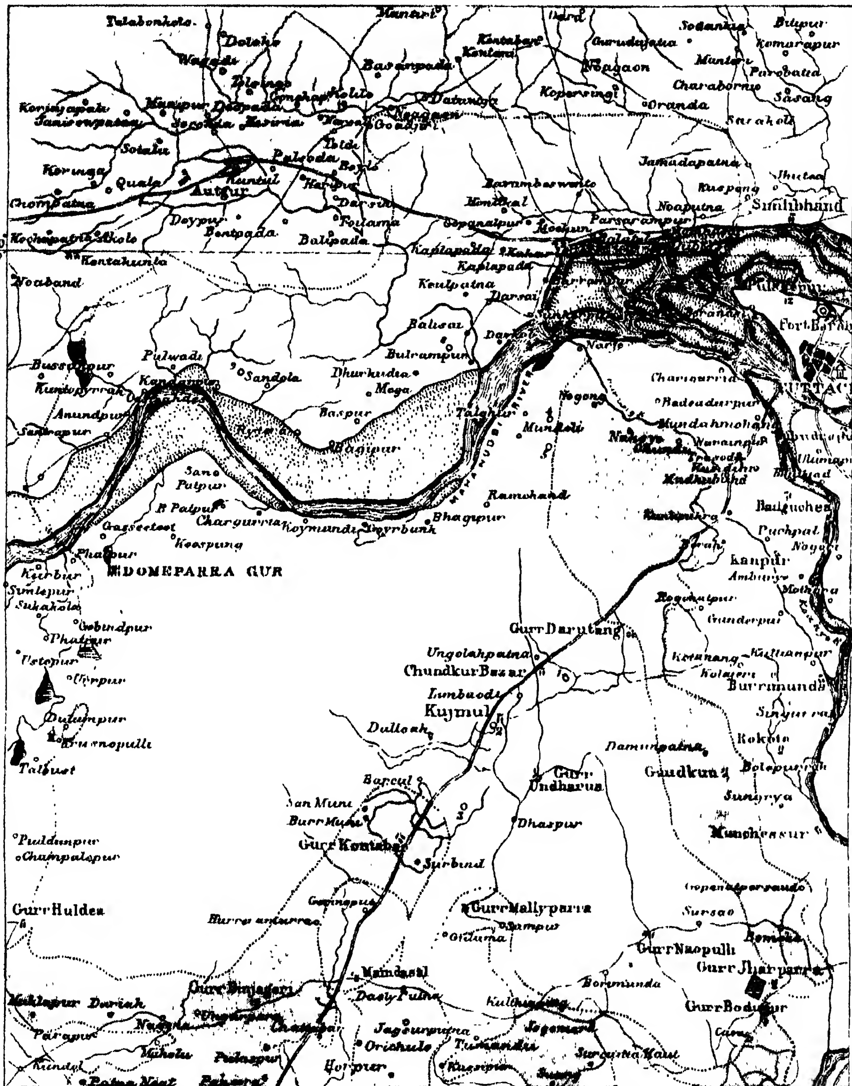
*a*. Tripetty sandstones and
*c*. Golapilly sandstones

of the Godavari District.

Further examination of the fossils of the Ragavapuram shales may show that they and the intermediate group of Sironcha are also synchronous.

## KADAPAHS AND KARNULS.

In the Chanda sheet to the north of Nandpa and Sakaravoye, I had an opportunity of seeing the quartzites, limestones and purple shales of the sub-metamorphic series already observed by Messrs. Blanford and Fedden. They strike me as certainly of the Kadapah and Karnul series of Madras, or of the Kaladghi and Bhima series of Western India.




# ATGARH BASIN

Scale 4 Miles - 1 Inch

INDEX OF COLORS & SIGNS

Alluvium Recent — Alluvium Laterite — Trap — Atgurh Sandstone — Gneiss

Boring Sites

It is, of course, necessary to remember that both purple shales and limestone, scarcely to be distinguished from each other in regions of disturbance, are found both in the Karnuls and Kadapahs; but as far as I could see, without having had any opportunity of going closely over the ground, the quartzites of the Nandpa hills are Kadapahs, just as I recognise the altered rocks of the Pakhal country to be of the same series. On the other hand, I should certainly consider that the limestones of the trap-capped plateau south of Kamána are Karnuls, or Bhimas.

Between Kamána and Sakaravoye I passed over an extensive belt of purple and grey shales which in some respects are very like certain slaty shales in one of the groups of the Kadapahs; but they do not present that clay-slate character possessed by all the shales of this series, and, on the whole, it would appear that these Sakaravoye beds are of the Bhima or Karnul series.

At the same time Mr. Hughes is of opinion that these purple shales, limestones and quartzites are not distinguishable into two series; consequently, if they are all of one series, they must preferably be considered as belonging to the newer of the two systems, *viz.*, Bhimas or Karnuls; and in certain parts of the field they have been so disturbed and crushed as to have assumed the more altered appearance and characters of the Kadapahs, which is also, I consider, the case with the Kistnah extension of the Karnuls in the Palnád country.

I am, however, hopeful that the Kamána rocks will be found to be separable into the two series, more particularly as they seem to be a north-westerly extension of the Bhimas and Kaladghis, and the shales and limestones are very like the first of these.

## ON THE 'ATGARH SANDSTONES' NEAR CUTTACK. *By* V. BALL, M. A., F. G. S., *Geological Survey of India.*

The principal result of my examination of the sandstones and conglomerates which lie to the west and south-west of Cuttack, has been the discovery of fossil plants whose affinities are sufficiently clear to admit of conclusions being drawn as to the age of the rocks which contain them.

That these rocks were of more recent age than the group or groups of rocks which occur above the coal-measures in the Tálchir-field was considered probable by Mr. Blanford*; but the non-discovery of fossils and the similarity of their general lithological characters with those of the rocks constituting the above-mentioned groups have hitherto prevented their certain correlation with the rocks of any recognised period in India.

This uncertainty being removed, the question of the probability of coal measures occurring underneath assumes a somewhat different aspect, but only perhaps a different aspect. The possibility of such occurrence still exists, even if the probability, in so far as theoretical considerations go, be lessened.

As bearing immediately on this part of the subject, reference need only be made to the Rajmehál hills, where—in part of the area—the coal-measures are directly covered by members of the series to which these rocks are now referred, while in other parts a considerable thickness of rocks belonging to a group distinct from both, intervenes.

* Records, Vol. V, p. 59.

The next points in the inquiry (the possibility of these rocks directly overlying the coal-measures being thus admitted from analogy) involve a general description of the local conditions, which may therefore be conveniently noticed at once.

The area occupied by these rocks covers about 60 square miles, spreading both to north and south of the Máhanadi Valley above Cuttack. It is covered with low hills and ranges which rarely, if ever, exceed 250 feet in height, and are generally of very much less elevation.

Both the hills and the intervening valleys are covered with a dense, thorny, secondary jungle which, throughout a large proportion of its extent, is absolutely impenetrable. Indeed, the central portion of these hills is an unoccupied waste without villages or cultivation. The trunk road and its vicinity afford an opportunity of examining a cross section in one direction, while the Máhanadi river yields a more or less broken one in another. Otherwise, examination of these rocks has to be conducted round the edges of the area where, however, the junctions are, with a few important exceptions, concealed by alluvium or laterite.

To the north of the Cuttack and Sambalpur road, between Kukkur and Daiserah, there are several ranges of small hills. Towards the east these are chiefly formed of laterite, owing to which, and the density of the jungle, it is impossible to define the limits and nature of the underlying rocks; but even if these obscuring causes were removed, the surrounding alluvium would render exact demarcation impossible. Still, from the existence of metamorphic rocks at no great distance to the north and north-east, there are known limits beyond which the sandstones cannot extend in those directions. Proceeding westwards through these hills, the laterite steadily lessens in amount, and towards their western termination the jungle is the only agent in the concealment of the rocks. Here there are coarse and loose-textured conglomerates with ferruginous sandstones; these rocks appear to be at the base of the group, and probably rest naturally on the metamorphic rocks which are seen not far off on the west.

The same rocks are seen in a stream crossed by the road about a mile east of Daiserah, between which and some schistose gneiss at the river-crossing near Sonkarpur, no rocks are exposed on or near the road. South of the road a spur from the main ranges between it and the river terminates in an abrupt scarp below the village of Hontikul. The rocks exhibited in this scarp consist chiefly of loose-textured, coarse-grained sandstones with occasional pebbles. Towards the top are some white clay beds, in one short length of which, and not elsewhere, I found the fossils described in a following paper by Dr. Feistmantel. The hills which occur to the south and south-west of Daiserah and between it and Malbadapur consist of white and ferruginous coarse-grained sandstones, generally capped by conglomerates, and invariably with horizontal bedding. At Malbadapur metamorphics appear, and the boundary, which seems to be quite natural, strikes southwards through the corner of the large lake or jheel, and thence to the south-south-east, where it passes under the northern end of the Gopalpur hill, where the sandstones and conglomerates are seen at the top, hornblendic gneiss forming the base. The sedimentary rocks alone appear at the southern end of the hill, where it impinges on the river, and are well exposed in section there. From the above it would appear that this portion of the boundary is natural, and that no beds exist between these sandstones and the metamorphics in this part of the area. It may be added that a similar section exists in the end of the hill which lies on the line of boundary between the rise at Gopalpur and the corner of the jheel, but owing to jungle, the section is less clear.

In the river section a slight dip of the sandstones from the boundary towards the east can be observed, but it is only a slight departure from the general horizontal position.

West of the above-described boundary, gneiss crops out in various places, forming low hillocks and ridges. There are two principal varieties: one felspathic containing garnets and sometimes magnetic iron, and the other hornblendic. Close to Kusanpur there is a bossy mass of granitic gneiss striking north-east—south-west, dip north-west.

From hence eastward the section exhibited along the northern bank of the Máhanadi gives the best view of the rocks that can be obtained; but owing to the general horizontality of the beds and the lowness of the hills, the total thickness exposed must be inconsiderable.

Between Gopalpur hill and those which touch the river at Phoolwari, a large fertile bay, encircled by ridges of sandstone, occupies the space, the rocks being covered up by alluvium. In the river channel, too, throughout this interval, no rocks are exposed. At Phoolwari the hills consist of the same sandstones and grits, with pebbles and a pudding-stone strangely resembling one which occurs at the top of the highest hills in the west of the Tálchir field. A dip to the south of these beds, where seen near the bank, I attribute to mere local undermining by the river.

In the channel of the river, below Phoolwari, is a small island formed of sandstones. These on the east shew a dip to south-east, but this, however, also appears to be only local and due to the action of the river.

Between Phoolwari and Balrampur the rocks above and under the river bank appear to be identically the same beds as those above mentioned—in their horizontal extension. In the hill close to the river near Bulrampur there are sandstones with a considerable cap of laterite; under the bank the section of the former discloses a dip of 10°-20° to south and south-west, but further inland the same beds are quite flat.

Between Bulrampur and the Sambalpur road the rocks where seen are of the same general character as before, but on the river bank at Maneshwar there are white sandstones with clays, and on the islet opposite a sandy false-bedded conglomerate of very recent aspect dips south-south-west at 7°.

On the southern bank of the river the sandstones first appear near the village of Naraj, below the Public Works Department bungalow, close to the point where the Máhanadi sends off its branch, the Kajuri. The sandstones here are somewhat loose-textured, strong silicio-felspathic rocks with partings of red and white clays. A quarry in active operation exposes a working face of about 30 feet high. The stones from this locality are largely employed, chiefly as ashlar for the irrigation works. Portions, however, dress fairly, and the general appearance resembles that of the sandstone quarried at Barákar. Inland from this, spreads of laterite and alluvium cover up and conceal these rocks, and in the Sideshar* hill, which is about a quarter of a mile further up the river bank, they are locally abruptly cut off by a vertical dyke of basaltic trap, from the opposite or southern side of which a thickness of about 80 feet of shales dips suddenly away at angles of 10°-12°. The sudden appearance of these shales suggests the existence of a fault, through the fissure caused by

* Under the heading "*Section of a Hill in Cuttack supposed to be likely to contain coal,*" Lieut. Kittoe gives a sketch and account of this hill, to which is appended a note by Dr. McClelland. The sketch, which was drawn by Dr. McClelland, is something in the willow-pattern style of art, but represents the relations of the rocks. Dr. McClelland calls the black and colored shales chalk, a term which is certainly not applicable to them. Neither is the term trachytic applicable to the basaltic trap. Some calcareous matter is stated to occur at the junction of the trap with the clay shales forming "a true vein," in which there are said to be "fragments of primary clay mechanically mixed with plates of silvery mica—ingredients which must have been derived from below." This vein was filled with rubbish from the top at the time of my visit. The occurrence of the clay-slate and mica is probably to be accounted for by a partial metamorphism caused by the dyke.

J. A. S. B., Vol. VII, 1838, p. 152.

which the dyke was doubtless thrust. Although the section in the river bank is quite clean, the thick covering of laterite on the hill and from thence inland renders it impossible to trace the limits of the trap and examine its relations with the sandstones in that direction. These latter, however, appear to sweep round the Sideshar hill to the east with unbroken bedding; further south, however, both shales and basalt are again met with, as will presently be noticed.

The trap on the river face extends for about 150 or 160 yards in a north-east, south-west direction, but this is probably oblique to the strike, and certainly so if the trap seen further south is continuous with it. It is a dense, heavy, greenish-black rock abounding in an earthy magnesian mineral, which in the exposed portion has been washed out and left hollows.

On the southern side of the trap occur the shales above mentioned; of these the lower portion is black and carbonaceous, but not in the smallest degree coaly; towards the top they become purplish and red, and include one or two distinct runs of ironstone. Unfortunately they do not shew any determinable remains of plants, a few charred fragments of vegetable matter being alone discernible. In general appearance, beyond the fact that they are carbonaceous, these shales do not present any resemblance to those of the coal-measures, while they are of much the same character as certain well-known beds in the intertrappeans of the Rájmehál hills. The hopes of coal occurring in this vicinity, which have from time to time been excited by the appearance of these beds, are not, I venture to say, justified by the facts. The appearance of these beds at the surface, in this locality, being probably altogether due to the elevatory action of the trap, and the fact that they have not been elsewhere observed in any part of the area, prevent any decided opinion being formed as to their extent. Judging, however, from the sections in the Rájmehál hills, it is not improbable that they may originally have had a very limited area of deposit.

The point at which they appear further south is situated about 500 yards to the east of the village of Mondali. Here, together with the trap, they have contributed to the formation of the soil, and are seen in certain shallow wells and excavations, but nowhere crop out at the surface.

Close to Mondali there is an unusually hard and dense felspathic quartzite. In the river section, at intervals up to Bajipur, there are outcrops of sandstone of normal character. In the vicinity of the bund in the direction of the river, certain black clays situated in the bank at about the hot-weather water-level, and which had been pointed out to me as being possibly indicative of coal, proved on examination to be of a peaty character and of the same age as the alluvial clays with which, indeed, they may be seen to be interbedded. Between this and Dompara the beds exposed in the river are flat, ferruginous sandstones, rarely accompanied by red clays. In the hills to the south of the road there are sandstones and conglomerates similar to those seen in the ranges north of the river.

Towards Talbust, a hill of metamorphic rocks occurs in close proximity to the sandstones, but no junctions were observed. The boundary is still probably natural, as the sandstones shew no signs of disturbance. Between Talbust and Huldia the rocks seen are massive beds of coarse sandstones and conglomerates, which are in places abruptly scarped.

Between Huldia and Maindasal, at the foot of the Tuskai hills, the boundary is completely hidden by laterite, under which the sandstones disappear. Springs are very abundant at the foot of the hills.

To the north of Mandasal there is a considerable area traversed by the road, in which metamorphic rocks occur. Owing to laterite, the limits of this area and the relations between the gneiss and quartzites occurring in it, with the surrounding sandstones, are very much obscured.

Between Mandasal and Bobaneshwar, sandstones of the same character occur, forming at Kandagiri the small hill famous for its enormous *gumpas* or cave temples. To the southwards and also to the east, at a point about a mile to the west of Bobaneshwar, the sandstones disappear under great spreads of laterite. The eastern limits of the sandstones in the country stretching northwards between this and Naraj are also effectually concealed by laterite. It is quite possible that the sandstones may stretch eastward for several miles under the alluvium of the delta.

Although in the foregoing pages these rocks have generally been spoken of as occurring horizontally, it seems to be the case that, viewed as a whole, there is a slight dip to the south-east.

Having now described the appearance of these rocks and enumerated the various data available, the question as to the probability of coal-measures occurring underneath them may now be resumed.

That there is no inherent impossibility of such being the case has been already demonstrated on a previous page. A basin of coal-measures, the edges of which have been overlapped, may possibly occupy the centre of the area, and it can only be in view of such a possibility that any exploration can be undertaken. As a matter of observation, the beds of sandstone are horizontal, or are practically so, and whenever their boundaries are not obscured by alluvium or laterite, and, consequently, the underlying rocks are exposed, the latter invariably prove to belong to the metamorphic series.

Owing to the occurrence of such metamorphic rocks at or close to the boundaries of the sandstones on the north, west and south sides, respectively, it is clear that if the hypothetical basin exists, its limits are overlapped in those directions, and it therefore follows that exploration by boring, if undertaken, should be directed chiefly to the eastern central portion of the area. For this purpose the vicinity of the trunk road is well situated, besides possessing other manifest advantages. Further to the east, and even in the station of Cuttack itself, borings might be made, which, in so far as anything is certainly known to the contrary, might be regarded as having an almost equal chance of proving coal-measures. But the difference in chance, slight as it is, together with the difficulty of carrying out a boring through a possibly considerable thickness of alluvium, should, I think, determine in favor of the former.

On the accompanying map I have marked the localities in which the borings might be made, the numbers indicating roughly the order of their relative importance. Nos. 1 to 5 would be the most important. If they proved, as they might do at a very small depth, that metamorphic rocks underlie the sandstones, without any coal-measures intervening, then it would be useless to proceed with the others.

In conclusion, I wish to make it quite clearly understood, that the indications do not appear to me to be such as to justify any good hopes of success, and consequently I cannot recommend any further expenditure being incurred for exploration by boring or otherwise. The decision as to boring-operations being undertaken resting with the Government, and the possibility of there being hereafter such a local demand for coal as to make it desirable to put the matter to a final test, are my reasons for having discussed the question of boring as above in detail.

*List of sites for borings in approximate order of their relative importance.*

| | |
|---|---|
| (1) North of Chandkar ... ... ... | On the Madras road, south of the Máhanadi. |
| (2) At Kujmul (Koojmool) ... ... .. | |
| (3) One mile east of Barcul (Burcool) ... ... | |
| (4) ½ a mile north-east of Fulghar ... ... | Near Naraj, on the Máhanadi. |
| (5) ½ a mile south-east of „ ... ... | |
| (6) One mile west of Goyrbank ... ... | On the south bank of the Máhanadi. |
| (7) South of B. Patpur ... ... | |
| (8) At Bolpada ... ... ... ... | On the north bank of the Máhanadi. |
| (9) At Kandarpur ... ... ... ... | |

NOTES ON FOSSIL FLORAS IN INDIA, *by* OTTOKAR FEISTMANTEL, M. D., *Palæontologist to the Geological Survey of India.*

IX, X, XI, XII AND XIII.

IX.—ON SOME FOSSIL PLANTS FROM THE ATGARH SANDSTONES.

The flora of the Atgarh sandstones, so far as known, is poor in species, but nevertheless sufficiently marked to enable us to recognise the period to which it belongs. Ferns prevail.

## FILICES.

ALETHOPTERIS INDICA, *O. and M. sp.* (PECOPTERIS, *O. and M.*).

This species is tolerably abundant. It was first described by M.M. Oldham and Morris in the flora of the Rájmehál hills (Pl. XXVII). I have elsewhere shewn that this Rájmehál species is very near to *Asplenites Rosserti*, Schimp. Lately I have found it to be not uncommon amongst the fossils from Golapilly near Ellore, and have made use of its occurrence there together with that of other fossils to prove that the Golapilly rocks belong to the Rájmehál group. The present is an analogous case from which a similar conclusion may be drawn.

Besides the common form of *Alethopteris indica*, O. and M. sp., there occurs a still smaller frond which, however, belongs also to *Alethopteris*, Göpp.

If we compare the drawings of M.M. Oldham and Morris' work (Pl. XXVII), we find that fig. 2 shews slightly different dimensions; similarly is the *Alethopteris* from Atgarh different from the common form. In order to mark the distinction, I would call the latter *Alethopteris indica*, O. and M. var. *minor*. This form is somewhat rare, the occurrence of the other being much more frequent.

ASPLENITES MACROCARPUS, *O. and M. sp.*

There is a fragment of a pinna, the pinnulæ of which show a slightly dentated margin, with an indication of fructification, as is also to be seen in *Pecopteris macrocarpa*, O. and M. I do not doubt that this fragment from Atgarh should be referred to this species. I have transferred it to the genus *Asplenites*, retaining the original specific name.

This species occurs pretty frequently among the fossils from the Rájmehál hills, and also occurs with those from Golapilly. I hope to make a comparison between this species and *Asplenites Ottonis*, Schimp., from the Rhætic strata.

GLEICHENITES BINDRABUNENSIS, *Schimp.*

There are some specimens of a fern which at once recall the species from the Rájmehál hills described by M.M. Oldham and Morris as *Pecopteris* (*Gleichenites*) *Gleichenoides*. Mr. Schimper considered it, however, to belong to *Gleichenia*, and has described it as *Gleichenia Bindrabunensis*, Schimp. This I believe to be correct, and I therefore adopt his name for the species.

The above species of ferns have already been recognised as characteristic of the Rájmehál group. I do not doubt that they here indicate the same group.

As appendix to the ferns I may mention the occurrence of the genus *Rhizomopteris*, *i. e.*, Rhizomes of ferns, which I describe especially further on.

CYCADEACEÆ.

*Cycadites confertus*, Morr. A single leaflet establishes the species; it agrees completely with Pl. VIII, fig. 2, in Oldham and Morris' Rájmehál Flora. As I think, the *Cycadites Blanfordianus*. Oldh., is to be placed to this species.

CONIFERÆ.

A branch, pretty well preserved, belongs no doubt to that species which was, for the first time, found in the Rájmehál hills and figured, but not described, in the Rájmehál Flora, (Pl. XXXIII) under the title *Taxodites indicus*, O. and M.

Subsequently Mr. Oldham himself admitted that this fossil belongs to the genus *Palissya*. I also have recognised it as such, and moreover proved it to belong there. The same form has been found also in the Jabalpur group of the Satpura basin. I have also identified it from Golapilly and Kach (Cutch). When describing it in my papers on the Kach (Cutch) and Rájmehál floras and giving the *diagnosis*, I thought it best, on transferring it to the genus *Palissya*, to call the species after Dr. Oldham, *viz.*, *Palissya Oldhami*, Fstm. I also published the same name in my notes on some fossil floras from India (Rec. 1877, Pl. II). This I thought to be justified by the fact that the species has never been described. My intention to thus change the name has, however, been objected to; so that to avoid any misunderstanding I have decided to use for this conifer form from the Rájmehál hills, Satpura, Kach, and Golapilly the former species name—*indica*. It will therefore stand as *Palissya indica*, Fstm., to which species also belongs our plant from Atgarh.

The specimen from Atgarh is a single branchlet, but quite distinct, the midribs in the leaflets being visible.

Genus: RHIZOMOPTERIS, *Schimper*, 1869.

Schimper: Pal. végétale, Vol. I, p. 699.

Nathorst, 1876,* page 14, Pl. I, figs. 8-13.

Rhizomes of ferns, either underground or superficial, distinct by their repeated ramification. They show the scars of the fallen-off peduncles, or contain the remains of the petioles, often covered with pile.

Schimper established this genus from two forms from the carboniferous formation. Lately, Mr. Nathorst described one species from the Rhætic of Sweden,* *Rhizomopteris Schenki* from Palsjo (l. c. p. 14, Pl. I, figs. 8-13).

* Nathorst: Bidrag Till Sveriges fossila flora, Stockholm, 1876.

Amongst the fossils brought by Mr. Ball, some specimens are to be referred to this genus. I describe them as—

RHIZOMOPTERIS BALLI, *Feistm.*, Pl. I, figs. 2-7.

*Rhizomate dichotome ramoso, cicatricibus petiolorum vestito, circiter, 10·14. Cm. crasso, ramis adæquantibus cicatricibus in quincunciam dispositis, circularibus sub-emarginatis fossula circulari circumdatis.*

The rhizoma apparently dichotomous set with scars, which are disposed in quincunx. They are circular, and surrounded with a circular line.

The specimens from Atgarh agree mostly with those described by Mr. Nathorst, especially Pl. I, fig. 10, while the other ones figured by Nathorst shew larger scars with a horse-shoe-like vascular mark, but fig. 10 has the same circular scars as the Atgarh specimens On two or three specimens the ramification (dichotomy) of the Rhizoma is well seen. In size they resemble also mostly those from Palsjo.

*Rhizomopteris*, Schimp., takes in the Fossil Flora amongst the ferns the same part as *Spiropteris*, Schimp., which comprises the circinnate vernation of fossil ferns, as *Rhizomopteris* comprises the rhizomata; and there can, of course, be as many different species of *Rhizomopteris* as species of ferns, supposing that all different species of ferns have also different rhizomes, but it might be very difficult to decide to which fern a certain *Rhizomopteris* should belong.

Here in the Atgarh strata near Cuttack ferns are prevailing, and the *Rhizomopteris* belongs to one of them. The species I devote to Mr. V. Ball, who collected it.

Some of the forms, which Mr. Schenk (Flora der Grenzschichten, 1867) figured as "*trunci filicum*," belong perhaps rather to this genus; and then the stem fragments from the Mangli beds, which I referred as very similar to Schenk's "*trunci filicum*," are perhaps also rather to be placed with *Rhizomopteris*. Now I think that also the specimen from Kach, which I figured, Pl. IV, fig. 3,* and discussed shortly (page 35) as Stem of "fern" (or Rhizome), would be rather a *Rhizomopteris*.

## X.—ON TRUE PTEROPHYLLUM FROM THE RANIGANJ FIELD, AND THE CYCADEACEÆ FROM THE DAMUDA SERIES.

Already in 1850 Dr. McClelland† described a real *Cycadeous* plant from the Damuda Series near Raniganj with the name *Zamia Burdwanensis* (Pl. XIV, fig. 4, p. 53 l. c.) This figure, however, he has taken from a set of unpublished plates of Burdwan fossils in possession of the Asiatic Society.

When subsequently Mr. Oldham wrote his paper on the age and the geological relations of the rocks in Central India and Bengal,‡ he thought justified, on account of the general badness of the drawings, as he had not the original before him, in doubting the accuracy of this figure, *Zamia Burdwanensis*, McCl.; and he could not help thinking that a fragment of a *Schizoneura* had in this case been mistaken for a *Zamia*.

Only lately, however, this disputed and very important specimen was found by Mr. Medlicott amongst some old collections. It shews that McClelland was completely

* Flora of Kach: Palæontol. Indicâ, 1876

† Report of the Geol. Surv. of India for 1848-49, Calcutta, 1850

‡ Memoirs Geol. Survey of India, Vol II.

J. Schaumburg ad nat. et Lith.
Printed at Geol Survey Office

right in considering it as a *Zamieæ* (though not *Zamia*). His figure agrees pretty fairly in outline with the original, so that there is no doubt that we have before us that specimen from which the figure in those unpublished plates was taken and which McClelland copied again; only the insertion of the leaflets and the veins are not quite correctly drawn. From these both, as also from the form of the leaf, I think that this specimen is rather a *Pterophyllum* than a *Zamia*.

I shall give here a short description, and as McClelland called it already *Zamia Burdwanensis*, I shall keep the same specific name; I give also a new figure of it.

PTEROPHYLLUM BURDWANENSE, *Feistm.*, Pl. I, fig. 1, 1*a* (McClell., sp.).

1850. *Zamia Burdwanensis*, McClelland: l. c. p. 53, Pl. XIX, fig. 4.

*Fronde mediocri, rhachide tenui (in specimine nostro!); pinnulis (foliolis) oblonge linearibus, æqualibus, subcoriaceis, tota basi insertis; basi paulo dilatatis, contiguis, apice obtuse acuminatis; nervis simplicibus, filiformibus, distantibus, 7-8 numerantibus.*

The specimen is only a fragment of a frond, with four leaflets on one side and two on the other; the frond seems to have been only of a middle size, as far as one can judge from the specimen. The leaflets measure 62 mm. length and are 8 mm. broad.

They are inserted by the whole base, and they seem to be slightly joined at their bases; the apex is obtusely acuminated. The rhachis of the frond in this specimen is very thin; it does not, however, follow that it was so throughout, as we see, for instance, the same relations in *Pterophyllum Medlicottianum*, O. M., from the Rájmehál hills; the specimen figured by M.M. Oldham and Morris* has a thin rhachis, while I have figured later two specimens, with a pretty thick rhachis.†

The veins are not numerous and rather distant; I could count seven to eight veins in one leaflet; they are very thin, though very well marked.

As to the relations of our specimen, I can say that it is next to those forms from the Rájmehál hills which were named *Pteroph. Carterianum*, Oldh., and *Pteroph. Falconerianum*, Morr., both of which, however, I treat as only one species, with the former name.

This species increases the number of the *Cycadeaceæ* from the Damuda Series. As I have mentioned in one of my last notes in the Records, I think it is very probable from the form of the leaf and especially from the relations of the veins that the *Zeugophyllites* from Australia, which by some authors is also referred to *Schizoneura*, is only a *Cycadeaceæ*, and belonging most probably to *Podozamites*, Br.

This *Pterophyllum* is, however, not the only *Cycadeaceæ* from the Damudas. I mentioned already several others which according to the opinions of most authors (beginning with Brongniart, 1838, and ending with Schimper, 1874) are to be placed to *Cycadeaceæ*.

To these belongs in the first place—

NÖGGERATHIA.

*Nöggerathia*, Strnb., is in our Damuda Series pretty frequent, and a *Nöggerathia Hislopi* was described by Sir Charles Bunbury 1861.‡ It is very well known that Brongniart already, 1833§, was convinced that *Nöggerathia* belongs to the *Cycadeaceæ*; later

* Rajmahal Flora: Pal. Indica, Pl. XVII, fig. 1.
† Rajmahal Flora Contin., Pl. XLIII, 2, XLIV, 1.
‡ Quar. Jour. Geol. Society, 1861.
§ Annales des sciences naturelles, 1833.

(1850) Goldenberg* was of the same opinion. Sir Charles Bunbury in general adopted Brongniart's views about *Nöggerathia*, and it seemed to him only doubtful whether it could not be a fern; but "the breadth and coarseness of the veins in the Nagpur plant, and a certain appearance of rigidity about the leaf," looked already to Sir Charles Bunbury rather like a cycad than a fern (l. c. p. 335), while the dichotomy of the veins, their equality and uniformity, and the absence of any trace of transverse connecting veins, plainly shews that it is not a Palm (l. c. 335), so that he would refer the plant rather to the *Cycadeaceæ* or an allied form. The resemblance of *Nöggerathia* in its well-defined characters with some *Zamieæ* is so striking, that there can be little doubt but that it belongs to this Order or very near. Already in previous papers (in Europe) I have considered *Nöggerathia* as gymnospermous, as also Professor Geinitz does. Schimper placed it (1870-72) quite distinctly with the *Zamieæ*, as first genus; and also in my Flora of Kach† I quoted *Nöggerathia* with the *Cycadeaceæ*, uniting *Nöggerathia* with *Cordaites* to a special family, which, however, is only partly so, as some *Cordaites* may belong elsewhere, while *Nöggerathia* remains a *Cycadeaceæ*.

If we compare the carboniferous *Nöggerathia folisa*, Stbg., with *Sphenozamites Rossi.*, Zigno, there is certainly a great similarity between them; and if we compare the fructification in Goldenberg (l. c. Pl. III, fig. 3) with the fructification of a living *Zamia*, there is certainly a striking resemblance. Our Damuda *Nöggerathia* resembles very much the leaves of some living *Zamieæ;* so that all evidence seems to prove the views of Brongniart, that *Nöggerathia* is a *Cycadeaceæ* and most probably a *Zamieæ*.

The *Nöggerathia* from the Damuda Series supports strongly this view; and there is especially a specimen from Barkoi in the Satpura basin since many years in our collections which shews two leaves in their natural position as they were inserted on the stalk.

Genus: MACROPTERYGIUM, *Schimp.*

Some of the triassic forms, which at first stood also with *Nöggerathia* and *Pterophyllum*, were lately separated by Mr. Schimper with a special name, *Macropterygium*, with two species, *Macropterygium* (*Nöggerathia*) *Bronni*, Schimp., and *Macropteryg.* (*Pterophyllum*) *giganteum*, Schimp. Of these one is also in our Damuda Series; I mentioned already in Records IX, 4, p. 141, a specimen from the Lower Godávari District as *Nöggerathia Vogesiaca*, Bronn., which is Schimper's *Macropterygium Bronni*, and there are from the Damuda Series in the Satpura basin for a long time exhibited several specimens of a *Nöggerathia*-like form, only that they are much longer than the usual forms, and I suppose them to belong to *Macropterygium*, somewhat allied to *Macropterygium Schenki;* a similar form I brought again this year from the Kurhurbalee coal-field, together with many other plants on which I shall report on a subsequent occasion.

As far as is known now (1877), cycadeous plants are not so rare in our Damudas, at least more frequent than we find them in Carboniferous and Permian strata. There are known, not regarding those cycadeous plants which I brought from the Kurhurbalee coal-field and which are not yet described, four genera of *cycadeous* plants in our Damudas; as it is rather an important point in the discussion on the relations of our Damudas, I shall give here the general view of the genera and species known to present date, with their localities and dates of discovery.

* Verh. d. naturf. Rheinpreuss Vereins, 1848, V.
† Pal. Indica, 1876, p. 38.

## *ZAMIEÆ.*

1. Genus: NÖGGERATHIA, *Sternberg*, 1828.

*Nöggerathia Hislopi*, Bunb., 1861. Already known to Rev. Hislop, and in 1861 described by Sir Charles Bunbury (Q. J. G. Soc.), who was not quite certain about the nature of this genus, but would rather refer it to the *Cycadeaceæ* or a neighbouring family.

Is known from Nagpur district (at first known from there), from the Satpura basin (many years in the collections).

*Nöggerathia sp.*, from Kurhurbalee coal-field, known since 1871 and brought again this year. The same form occurs in the Tálchir shales.

Genus: MACROPTERYGIUM, *Schimper*, 1870-72.

*Macropterygium comp. Bronni*, I think a specimen (respect. two, as positive and negative impressions) from the Lower Godávari District (since 1873 in the collections), belongs to this genus, and also very near to the same species. So much is at least certain that they are *Cycadeaceæ*.

Genus: PTEROPHYLLUM, *Bgt.*, 1828.

One species is known.

*Pterophyllum Burdwanense*, Fstm. (McClell. sp.), which I describe now with this name, but which already by McClelland was figured (1848-49) as *Zamia Burdwanensis*. From the Raniganj coal-field.

Genus: GLOSSOZAMITES, *Schimp.*, 1870.

*Glossozamites Stoliczkanus*, Fstm. Only lately described by me, but since 1871 amongst our fossils from Domahani, Kurhurbalee coal-field, with a small suite of other plants, amongst which three coniferous branchlets already at that time were determined as *Voltzia heterophylla*, Bgt., which I found again so frequently this year.

These *Cycadeaceæ* from Kurhurbalee coal-field are the more important, as from the close connection of the Kurhurbalee coal-bed and the Tálchir strata, as regards both the stratigraphy and palæontology, I consider the Kurhurbalee beds as the lowest, or at least as low as the other representatives of the Barákar group and the Tálchir shales in close connection with it.

From the importance which the *Cycadeaceæ* have for us, I thought it useful to draw attention to these remains before they can be published with full descriptions and figures.

### XI.—NOTE ON PLANT FOSSILS FROM BARÁKAR DISTRICT (Barákar group).

In the beginning of this year I had an opportunity of visiting those beds of the Raniganj coal-field which were designated as the Barákar group. I procured many fossils from the mines in Kumardhubi (near Barákar), and collected some also in the most western part, near Nirscha.

The fossils, which come everywhere from above the coal seam and partly from bands in it, show a great uniformity of forms, and are throughout the same as we find them in the "iron shales" and in the Raniganj group of the same coal-field excepting the *Schizoneura*, which occurs as well in the Panchet group.

I determined from near Kumardhubi—

EQUISETACEÆ.

1. *Phyllotheca indica*, Bunb.—Stalks of equisetaceous plants determined with this name.
2. *Vertebraria indica*, Royle.—Very frequent; good specimens.

FERNS.

3. *Glossopteris communis*, Fstm.—A form with a pointed leaf, with incurved veins forming very narrow meshes. Very common through the whole Damudas.
4. *Glossopteris* with parallel, long and wide meshes.
5. *Glossopteris* with straight veins, forming narrow meshes.
6. *Glossopteris* with very wide and long meshes These will be described subsequently.
7. *Gangamopteris*.—Some two or three fragments I suppose to belong to *Gangamopteris cyclopteroides*, Fstm.
8. *Tæniopteris*.—Two specimens, with narrow veins.
9. *A Fruit*, which is not unlikely a cycadeous fossil.

From the western part near Nirscha I determined—

EQUISETACEÆ.

1. *Vertebraria indica*, Royle.

FERNS.

2. *Glossopteris stenoneura*, Fstm.—With very equal, long and very narrow meshes.

Of these *Vertebraria indica*, *Phyllotheca indica*, and most of the *Glossopteris* species, occur also in the Raniganj group; if we now add, that in the Barákar group of Tálchir near Cuttack there is known *Sphenophyllum trizygia*, Mig., *Sphenopteris polymorfes* (the same as in the Raniganj group), besides most of the *Glossopteris* species, there certainly remains almost only *Schizoneura Gondwanenis*, Fstm., as peculiar to the Raniganj group, while most of the other fossils it has in common with the Barákar group, and moreover all the fossils which have been found as yet in the Iron Shales are identical with the same, both in the Raniganj and Barákar groups.

The close relation of the Raniganj group with the Panchet group (see further on) is unquestionable, by the continuation of the same *Schizoneura Gondwanensis*, Fstm.; so that all these circumstances shew distinctly rather a continuation of forms from one band to the other, than any distinct break or interruption of deposition and of life, and support, therefore, the view of a more uniform epoch of time.

The Kurhurbalee coal strata of which I shall speak in a following number are certainly as old as the Barákar group in other districts, if not lower, as they are so closely connected with the Tálchirs in stratigraphy and fossils; and as the Kurhurbalee flora has most allies in Triassic times. the other strata can scarcely be older.

XII.—FOSSIL PLANTS FROM NEAR ASSENSOLE (Raniganj group).

Staying at Assensole, I visited the Nunia to see the Panchet group. In a north-west direction the stream traverses first some strata which were termed the Panchet group, where the *Schizoneura Gondwanensis*, Fstm., was collected. I failed to observe the slightest unconformity or difference between these strata and those in which the outcrop of coal with fossils of the Raniganj group occurs above the village Khumarpur; so that, here at least, the stratigraphy would admit of the relation I have suggested from the fossils. The coal seam outcropping in that part of the Nunia stream and the strata with it have quite the same dip as the overlying strata assigned to the Panchet group. Some strata above the outcrop are not to be distinguished from those of the Panchet group, and contain *Glossopteris*, so that I have no doubt that this genus passes into the Panchet group. The respective specimens are in our collections.

Below the coal-seam a thick band of fine-grained sandstone of yellowish color, full of *Vertebraria indica*, Royle, is lying. No other fossils were found in it.

In the carbonaceous shale with the seam I collected—

1. *Vertebraria indica*, Royle.
2. *Glossopteris*, with wide meshes, like those I mentioned from the Barákar group.
3. *Glossopteris*, with a round leaf, some of which I know from Raniganj. It will be described together with those from Raniganj.

Completely the same *Glossopteris* with wide meshes I observed in the mines of the Beerbhoom Coal Company near Dadka. The seam is the same. It lies in the Nunia stream almost on the boundary marked on the map between the Raniganj and Panchet groups in that locality. It has exactly the same dip (south) as the overlying strata, the same relations as have the Tálchir strata, to the overlying coal strata in Kurhurbalee coal-field. In a southern direction from Assensole I followed the Nunia to beyond Beldánga. South-east of this place a seam crops out with a southern dip. As in the outcrop in the northern part of the Nunia, the shales were much decomposed by the influence of the water, so that with great difficulty only a few plants could be got out. It was especially a very thin stratum of shale above the coal which contained the fossils; I could determine the following species:—

1. *Vertebraria indica*, Royle, is the common form.
2. *Phyllotheca indica*, Bunb.—Some equisetaceous stalks.
3. *Glossopteris.*—Prevailing, a form with very narrow leaves, of which the veins, however, were different from those in *Glossopteris angustifolia*, Bgt. I refer it to *Glossopt. leptoneura*, Bunb., from Kamthi; again another species to connect the Raniganj and Kámthi groups as the same horizon.
4. *Gangamopteris*—A species with a narow leaf, though different from *Gangamopteris angustifolia*, McCoy. I shall describe it hereafter; it is from Beldánga.

It is the second instance of this genus in the Raniganj field, which is so frequent in the Kurhurbalee field, and almost the only fossil in the Tálchirs; in the latter two the species are identical.

The localities of fossils mentioned above are new for us as such, but they shew again the same character of flora as we are accustomed to see in other localities in the Raniganj and Barákar groups.

### *XIII.—Explanatory note on Glossopteris and Gangamopteris.*

I wish to make a few remarks explanatory of some statements in my paper on the homotaxis of the Gondwána system.* I do so at the request of Mr. W. T. Blanford, and most willingly, as it may explain some misunderstandings which I never intended.

Both these statements are on page 122. The one refers to the occurrence of *Glossopteris* in Australia. When I said that there would with great difficulty be found one species common with our Damudas, I referred to the lower beds, because, as far as I know the fossils, it is so; while with the *upper* beds (I mean those without animal fossils) there will be more species identical. My contradiction referred, therefore, to the identity of species of *Glossopteris* in the Damudas and lower coal-beds in Australia.

The second statement which I have to explain is about *Gangamopteris*, which Mr. W. T. Blanford mentioned as having been detected by me in the lower coal-beds in Australia. I must confess that from a cursory inspection a specimen seemed to me to be *Gangamopteris*, and I mentioned this determination to Mr. Blanford, without, however, the intention of having it published. When Mr. Blanford published this determination, which afterwards proved wrong, I had to contradict it, but omitted to say that the fault was on my side, as the determination was only a superficial one and not correct.

## NOTICES OF NEW OR RARE MAMMALS FROM THE SIWALIKS, *by* R. LYDEKKER, B. A., *Geological Survey of India.*

Since my last notice of Siwalik Mammals, Mr. Blanford has sent from the Manchhar (Siwalik) rocks of Sind a small, but very interesting, collection of mammalian teeth; among the species in this collection the following are new to the Sind area, *viz.*:—

*Sanitherium Schlagintweitii*, Meyer.
*Chœromeryx silistrensis*, Pentland, sp.
*Hyopotamus palæindicus*, sp. nov. nobis.
*Merycopotamoid*, gen. non. det.
*Sus hysudricus*, Falc. and Caut.
*Acerotherium perimense*, Falc. and Caut.
*Amphicyon palæindicus*, nobis.

Of the most important of these specimens I now give short notices, preparatory to fuller descriptions and figures; in the present paper I have also noticed specimens of the teeth of two genera of Mammals new to the Siwaliks, collected by Mr. Theobald in the Punjab; the upper molars of a new genus of Siwalik *Hippopotamoid* are also shortly described; as well as two lower molars of what appears to be a new species of Trilophodont *Mastodon*.

### ARTIODACTYLA.

#### SANITHERIUM SCHLAGINTWEITII, *Meyer.*

This genus has been hitherto known only by some molar teeth of the lower jaw, from Kushalghar, which will be found figured on Pl. 9 of "Indian Tertiary and Post-Tertiary Vertebrata:"† among Mr. Blanford's collection there are two upper molar teeth

* Rec. Geol. Survey, India, IX, 4.
† Palæontologia Indica, Ser. X, part 2.

of a small suine animal, which cannot be referred to any European fossil genus, and which from their size I have no doubt belong to the present species. The masticating surface of one of these teeth is raised into four cones, separated by a cruciform valley, of which the antero-posterior division is very shallow; there is an accessory cone behind the two anterior cones; the whole crown is surrounded by a crenulated cingulum; the dimensions of one of the specimens are as follows:—

| | Inch. |
|---|---|
| Length ... ... .. .. .. .. ... | ·55 |
| Breadth .. .. .. .. ... ... ... | ·52 |
| Height of crown .. .. .. ... .. .. | ·29 |

The excess in size of this tooth over the lower molar of *Sanitherium Schlagintweitii* is proportionate to the excess in size of the upper over the lower molars of the pig. The upper molars seem to be nearest to those of *Chœrotherium*, but are distinguished by the greater proportionate length of their antero-posterior diameter, and by the larger size of the fifth tubercle on the masticating surface.

### CHŒROMERYX SILISTRENSIS, *Pentland, sp.*

This genus has been hitherto known only by three specimens of upper molars from Caribari (Garo hills, N. E. Bengal)* which were originally figured by Pentland in the second volume of the second series of the "Transactions of the Geological Society of London," under the name of *Anthracotherium silistrense;* the genus *Chœromeryx* was subsequently made by M. Pomel† for the reception of these specimens: the original specimens are now in the Museum of the Geological Society. Figures of these specimens are also given on Pl. 68 of the "Fauna Antiqua Sivalensis." Mr. Blanford has sent down a single right upper molar tooth of this species, which exactly corresponds with the larger of the original specimens, and which therefore requires no further description here. This rare tooth is extremely valuable as shewing that the Bengal rocks are on the same horizon as the typical Siwaliks of Sind. It is very remarkable that the only known teeth of this genus have been found in two localities so far removed from each other as Sind and N.-E. Bengal.

### HYOPOTAMUS PALÆINDICUS, *n. sp. nobis.*

Up to the present time the last noticed genus has been the only one of the pig-like animals with five-columned teeth which has been found in India; the exclusively Indian genus *Merycopotamus* differing from its European congeners by having only four columns on its upper molars. Among Mr. Blanford's collection there are two upper molar teeth, one much worn, and the other only touched by wear, which belong to a species of Selenodont pig-like animal, but which carry five columns on the crown, in place of the four of *Merycopotamus;* the additional column occurs between the outer and inner columns of the anterior half of the tooth, occupying the same position as in the genus *Hyopotamus.* The general form of the tooth is very like that of *Hyopotamus velaunus;* the outer surfaces of the outer pair of columns of the Indian specimens have, however, a larger median ridge, and in this respect resemble *Merycopotamus.* The form of the worn dentine surfaces is like *Hyopotamus.* From the presence of five columns on the crown of the Sind specimens, I have referred the specimens, at all events provisionally, to the genus *Hyopotamus,* with the specific name of *palæindicus;* further discoveries may shew that the specimens belong to a new genus intermediate between *Hyopotamus* and *Merycopotamus:* in any case, the specimens are of great interest, in shewing that the two last mentioned

* The locality is given by Colebrooke (Tr. G. Soc., Lon., Ser. II, Vol. I, p 132)—the left bank of the Brahmaputra, above Mohendroganj. The river has moved westward since then.

† Compt. Rendus, 1848, p. 687.

genera are more closely connected than supposed by Professor Kowalevsky in his memoirs on the *Hyopotamidæ*. The dimensions of the least worn of the two teeth are as follows:—

| | |
|---|---|
| Length | ·8 |
| Breadth | ·89 |
| Height of crown | ·45 |

The genus *Hyopotamus* in Europe ranges from the Upper Eocene to the Lower Miocene; in Sind it is obtained from beds which immediately overlie strata of Upper Miocene age.

### NEW GENUS OF MERYCOPOTAMOID.

A large and complete upper molar tooth, scarcely touched by wear, is among Mr. Blanford's collection, which belongs to the same type of teeth as those of *Merycopotamus*, but which cannot be referred to this or any other known genus. The tooth carries four crescentoid columns on the masticating surface, which are relatively higher than those of *Merycopotamus*; the general form of these columns is the same as in the latter genus, with one important exception, which is that the external surfaces of the outer pair of columns are simply concave; they lack both the bold median ridge and the reflected anterior and posterior borders which characterise the teeth of *Merycopotamus*; the tooth has a well marked cingulum, as in the latter genus. The dimensions of the specimen are as follows:—

| | |
|---|---|
| Length | 1·13 |
| Breadth | 1·1 |
| Height of crown | ·81 |

I hope that additional specimens will be forthcoming to further elucidate the affinities of this specimen.

### ANTHRACOTHERIUM PUNJABIENSE, *n. sp. nobis.*

Among a large collection of teeth collected in the Siwaliks of the Punjab by Mr. Theobald during last year, I have lately discovered a portion of a lower jaw which undoubtedly belongs to the above genus. The discovery of this genus, like *Hyopotamus* in the Siwaliks, is very remarkable, if the specimen has been obtained from the same horizon as that from which the majority of fossils come, since in Europe the genus is not found in strata newer than the Lower Miocene. It is, however, quite possible in this case, though not in the case of *Hyopotamus*, that the specimen may have been obtained from a lower zone in the Siwaliks than the one which yields the majority of vertebrate fossils: the greater number of the specimens obtained from these deposits are either gathered from the washed-out debris of the rocks by native collectors, or obtained by them from the villagers. If the specimen is from the normal fossiliferous zone, it affords another instance how in one region a genus may live down to a very much later period of time than in another; and so how the faunas of what are two distinct periods in one region may all appear in the same period in another region.

The specimen in question consists of the hinder portion of a right ramus of the mandible, containing the two last molars. The inner columns of the barrels of these teeth are approximately conical (bunodont), while the outer columns are concave internally (selenodont); the anterior extremity of the hindmost outer column joins a process from the inner column, so that the intermediate hollow is closed anteriorly and open posteriorly; the last molar has a large talon-column which is concave anteriorly, and which gives off a central process to join the postero-external column. The teeth are almost identical in general form with those of the European *A. magnum*, but are of very much smaller size (they are unlike those of the smaller species from Rochette). The dimensions of the specimen are as follows:—

| | Inch. |
|---|---|
| Length of last molar ... ... ... . ... .. | ·92 |
| Width of ditto . . . . ... ... ... | ·44 |
| Length of penultimate molars . . ... ... ... ... | ·6 |
| Width of ditto ... ... ... ... . . | ·42 |
| Depth of jaw (broken) ... ... ... ... ... | ·95 |
| Thickness of ditto ... ... ... ... ... ... | ·5 |

Although these teeth belonged to an animal of about the same size as *Chœromeryx*, they cannot be referred to that genus, as they present no generic points of difference from the teeth of the European species of *Anthracotherium*, which we should expect to occur in the lower molars of *Chœromeryx*. The only other mention of *Anthracotherium* among Indian Tertiary Mammalia is given in Dr. Falconer's paper on the Perim Island fossils (Palæontological Memoirs, Vol. I, p. 395), where certain teeth sent to the Asiatic Society of Bengal were doubtfully referred by the late Mr. James Prinsep to the genus *Anthracotherium;* I have no means of knowing whether or not this identification was correct, as the specimens seem to have been lost.

Since publishing some notes on the osteology of the allied genus *Merycopotamus*, in the ninth volume of the Records of the Geological Survey of India (page 144), I have had the opportunity of seeing a table of descent of the genera of the Ungulata published by Professor Kowalevsky in the twelfth volume of the German "Palæontographica," after the perusal of which I am led to make a few additional remarks on the affinities of the genus *Merycopotamus* and its allies.

In a table which I have published in the "Palæontologia Indica" (Ser. X—2, Vol. I—2, p. 60), I have placed the genus *Merycopotamus* provisionally in the family *Anthracotheridæ*, remarking that the genus presents points of affinity in the form of its teeth (selenodont) to *Anthracotherium* and *Hyopotamus*, and in the form of its lower jaw to *Hippopotamus;* the same conclusion was intended to have been given in the above-quoted paper for the Records, only by an unfortunate slip the words *Hippopotamidæ* and *Anthracotheridæ* have been transposed in the twelfth line from the bottom of page 153. The close connection of *Merycopotamus* with *Hippopotamus* is noticed by Professor Huxley, who states in his "Anatomy of Vertebrated Animals" (Ed. 1871, p. 375) that this animal "appears to have been a Hippopotamid, with upper molars having a quadri-crescentic, ruminant-like pattern."

Reverting now to Professor Kowalevsky's table of affinity, we find that the genera *Anthracotherium*, *Hyopotamus*, and their allies, are supposed to have taken their origin from some more generalised type of Hyopotamoid animals in the lower Eocene period, which common stock also gave origin to the more modern group of Ruminants. At this lower Eocene period, according to Professor Kowalevsky, the primitive Artiodactyla (*Paridigitata*) had already differentiated into the two groups of *Selenodonta* and *Bunodonta*, the early hyopotamoids being a lateral off-shoot of the first group; these two groups have since that time pursued separate courses of evolution, and have had no connection one with the other. The genus *Hippopotamus* took origin from a lateral off-shoot of the Bunodonta; this genus, therefore, which has a typical bunodont dentition, can have had no direct connection with the Hyopotamoid stock since the early Eocene period.

The genus *Merycopotamus* is not introduced into Professor Kowalevsky's table; there can, however, be no doubt but that since its teeth are very markedly selenodont, the genus would be placed somewhere near the *Anthracotheridæ* (or *Hyopotamidæ*, for the family is known by both names) and entirely apart from the *Hippopotamidæ*. In his Memoir on the Osteology of the *Hyopotamidæ*, published in the "Philosophical Transactions" for 1873, Professor Kowalevsky refers to the genus *Merycopotamus* at page 25 as belonging to a group nearly related to *Hyopotamus*, though it seems probable that the Professor would place the two genera in distinct families, owing to the upper molars of the Indian genus having only four cusps or cones on the masticating surface, while those of the European genera carry five. Whatever be the exact family position of the Indian genus, it is perfectly clear that according to Kowalevsky's plan of evolution there can have been no connection between the original stocks of *Hippopotamus* and *Merycopotamus* since the lower Eocene period.

I have already noticed in my former paper the very remarkable similarity in the form of the mandibles of *Hippopotamus* and *Merycopotamus*; and I think every one must admit that these two genera must have descended from some common ancestor which had a somewhat similarly shaped mandible. Now, neither of these two genera is known in the fossil state from strata older than the Siwalik period; while no other Pig-like animal, either recent or fossil, has a similarly shaped lower jaw, though there is a very slight rudiment of the descending process in the American Peccari and *Hyopotamus*; it is further a very noteworthy fact, that the lower jaw of the Siwalik *Hippopotamus* (as is well shewn in Pl. 61 of the "Fauna Antiqua Sivalensis") which is the oldest known species of the genus, is very much more like that of *Merycopotamus* than is the lower jaw of the living species; indeed, except in the matter of size and of the form of the teeth, the jaws of the two Indian forms are almost indistinguishable. If the common ancestor of these two genera had lived as far back as the lower Eocene period, it is extremely strange that the remarkable configuration of the lower jaw should have persisted in these two isolated genera up to the Siwalik period, and that there are no traces of any fossil forms with similarly shaped lower jaws which lived between the Eocene and Siwalik periods; it is therefore probable that the hypothetical ancestor of these two genera lived subsequently to the Eocene period; and that the Bunodonta and Selenodonta are more closely connected than Kowalevsky supposes.

With regard to this hypothetical ancestor, we may notice that *Merycopotamus* exhibits such affinities to the older Hyopotamoids of Europe, now known for the first time in India, that it is almost certain that the ancestral form must have been selenodont or hemi-selenodont, and that, consequently, *Hippopotamus* is descended from a selenodont and not from a bunodont ancestor. In favour of this view we may note the very significant fact that, in tracing back the affinities of *Hippopotamus*, Professor Kowalevsky has not been able to place a single genus between it and the primitive bunodonts of the early Eocene. If this view be true, the bunodont teeth of *Hippopotamus* are an instance of reversion to an older type; in confirmation of this view we may notice that the pig-like animals with selenodont teeth, like *Merycopotamus*, *Hyopotamus* and *Oreodon*, have all disappeared from the earth, and evidently belonged to a type which was not suitable to persist in that condition; this type is admitted to have been modified into the true Ruminants, and it is quite likely that another branch of it may have reverted to the bunodont type. It seems to be probable that the more specialised selenodont type of tooth, though advantageous to the true Ruminants, was not suitable to those animals which retained the general organisation of the Pigs, and that these animals either were further modified into more specialised groups, or died out, or reverted to the more generalised bunodont type.

The resemblance in structure between *Hippopotamus* and *Merycopotamus*, whether the above explanation be fully accepted or not, clearly points to some closer connection between the *Selenodonta* and *Bunodonta* than appears from Kowalevsky's table. In that table the term *Bunodonta* is used as equivalent to the *Suina*; but it appears to me much more natural to use the latter term in its older and wider sense as comprehending the pigs, the hippopotamoids, the hyopotamoids, and the anoplotherioids, since all these animals are related in many essential parts of structure; the two former groups will belong to the smaller division of *Suina Bunodonta*, and the two latter to the second similar group of *Suina Selenodonta*; from which latter the more specialised *Selenodonta* have been developed as a lateral off-shoot.

HIPPOPOTAMODON SIVALENSE, *n. gen., nobis.*

The specimen for which I propose the above new generic name consists of a portion of a left maxilla of an animal allied to *Hippopotamus*, but which cannot be referred to that or any other known genus. The specimen has been for some time in the Indian Museum, and was collected by Mr. Theobald near the village of Asnot, in the Punjab, from upper Siwalik strata. The fragment shows the commencement of the zygomatic arch, and some portion of one-half of the palate; two nearly complete teeth, and a fragment of a third are preserved. The three teeth appear to be the three true molars; the last of these, being the most complete, is here selected for description.

This tooth has a nearly square crown, which is produced into four cones or columns, one placed at each angle; these columns are separated by a deep but narrow cruciform valley; between the four chief columns there is a small fifth column; while still smaller accessory columns occupy each of the four outer extremities of the cruciform valley; a crenulated cingulum occupies the fore and aft extremities of the crown. The main columns are semi-cylindrical in shape, and have infoldings of enamel from in front and behind, so that their worn dentine surfaces have somewhat of a trefoil shape, though this is not so marked as in *Hippopotamus*. The last tooth is placed immediately below the anterior root of the zygoma, as in the pig. The dimensions of the two last molars are as follows:—

| | | | | | | |
|---|---|---|---|---|---|---|
| Length of last molar | ... | ... | ... | ... | ... | 1·4 |
| Breadth of ditto | | ... | . | ... | ... | 1·29 |
| Height of crown of last molar | | ... | .. | ... | .. | ·7 |
| Length of penultimate molar | | ... | . | ... | ... | 1·1 |
| Breadth of ditto | | .. | .. | ... | .. | 1·05 |

The teeth are nearest to those of *Hippopotamus*, but are distinguished by the presence of the central fifth column, by the relative size of the other four accessory columns, by the crown being much lower, by the greater depth of the transverse valley, which extends to the base of the crown, by the form of the worn dentine surfaces, and of the cingulum, and lastly, by the position of the ultimate molar below the anterior zygomatic root.

The teeth of this new genus have no close resemblance to the molars of *Tetraconodon*; those of the latter genus, among other distinctive points, have wide open valleys, cylindriform columns, and no cingulum.

## PERISSODACTYLA.

### HIPPOTHERIUM THEOBALDI, *nobis*.

*olim :* SIVALHIPPUS.

In the last number of the "Records" (p. 31) I described a maxilla of a species of horse from the Siwaliks, which I then thought necessary to refer to a new genus, and for which I accordingly proposed the name of *Sivalhippus;* I now find that the specimen must probably be referred to *Hippotherium,* though it presents certain abnormalities which will perhaps subsequently render it necessary to make it sub-generically distinct, in which case the term *Sivalhippus* may be retained for the sub-genus.

In referring the specimen to a new genus, I was led to believe that the four protruded teeth belonged to the premolar series, in which case they would be exceedingly different from those of *Hippotherium ;* I now find, after removing some more matrix, that the teeth must belong to the milk-molar series, in which case they are like those of *Hippotherium* in form, though they differ in the rate of succession.

I was led to consider the four teeth as premolars and not milk-molars, because they have only just come into wear, and yet behind them there is the alveolus of a fifth tooth, which must have been protruded from the jaw; now, in other horses, this fifth tooth, or first true molar, would not have pierced the jaw until the milk-molars had been considerably worn down, and until their vertical successors were visible in the jaw above them, which is not the case in the present specimen; on the supposition, however, that the visible teeth are premolars, the first molar must have been more worn than they, and must have left a disc of pressure against the last of the first series. I now find after further clearing, that the last protruded tooth of the specimen does not exhibit any disc of pressure behind, and that, consequently, the fifth tooth, or first molar, could not have been in use, but had merely cut the gum; this tooth was therefore newer than the first four teeth, which must consequently be milk-molars, and not premolars as at first supposed.

From the above explanation it will be evident that this species of *Hippotherium* differs from the true Horses, and, as far as I can gather, from other species of the genus, by the unusually early period at which the first true molar appears,—almost as soon as the milk-molars are touched by wear and before their vertical successors have shewn in the maxilla. In the genus *Equus* the first true molar does not appear until between the eleventh and thirteenth month, when the milk-molars have been greatly worn down, and when their roots have been to a great extent absorbed by the premolars.

The teeth of the present specimen are too large to belong to the milk dentition of *H. antilopinum,* but they may probably be referred to the larger Siwalik species, which H. von Meyer identified with the European *H. gracile,* but which I have found, as already stated in my last paper, to differ somewhat from the European species in the form of its upper permanent molar series; this larger species will, therefore, now be known as *H. theobaldi.* The rate of succession of the dental series, together with the unusually large size of the lachrymal depression in the adolescent maxilla, sufficiently distinguish the species from the European *H. gracile.* The Indian Museum also possesses specimens of the first median phalange of the foot of this species, which is extremely different from the corresponding bone in the European species, or in the smaller Indian *H. antilopinum ;* there is, therefore, no doubt of the very aberrant nature of the larger Indian species, though from the resemblance of its upper molars to those of typical forms, I think it best for the present to retain it in the genus *Hippotherium,* and to drop the proposed name of *Sivalhippus ;* the question will be more fully discussed on a subsequent occasion.

## PROBOSCIDIA.

### MASTODON (TRILOPHODON) *sp. nov. ?*

No species of Trilophodont *Mastodon* has hitherto been known from the Siwaliks, though one species—*M. pandionis*—has been found in the Deccan. I have now to announce the presence of a species in the Siwaliks; this species is known by two lower molar teeth, one of which is the last milk-molar, and the other is the penultimate true molar. Both specimens were collected last year by Mr. Theobald from the Siwaliks of the Punjab.

Each of these teeth carries three transverse ridges and a fore and aft talon; the presence of only three ridges on their teeth shews that they cannot belong to either of the two Indian Tetralophodont *Mastodons* (*M. latidens* and *M. perimensis*) or to the aberrant Pentalophodont *M. sivalensis;* in the first of these groups only the very small second milk-molar is trilophodont, while in the second group only the first, and perhaps the second, milk-molars are trilophodont.

Both the present specimens belong to the wide-toothed *Mastodons;* the ridges are divided by an antero-posterior median valley; the first two pairs of columns are placed in the same transverse line, but the third pair are placed somewhat unsymmetrically; there is a large quantity of cement in the valleys, which of itself would be a sufficient distinction from the other Indian species: the transverse valleys are fairly open. The length of the larger specimen is 6·8 inches, and its breadth 3·7 inches: the length of the last milk-molar is 4·1 inches, and its breadth 2·4 inches.

The teeth have not the complex crowns of the Trilophodont *Mastodon pandionis;* it is therefore quite clear that they are distinct from all other Indian species of the genus; I believe they are also distinct from any European species. If the latter should prove to be the case, I should propose to call the present species by the name of *Mastodon (Trilophodon) Falconeri* in honor of the describer of the many other forms of extinct Indian Proboscidia.

## CARNIVORA.

### PSEUDÆLURUS SIVALENSIS, *n. sp.*

Mr. Theobald's Siwalik collection from the Punjab contains one-half of a lower jaw of a Feline animal with four pre-molars which consequently belongs to this genus; the specimen belonged to an animal of about the size of a small Leopard. The carnassial tooth is of the normal Feline type: only two other specimens of the genus *Pseudælurus* are known, one from the Miocene of Sansans, and the other from the Pliocene of Nebraska. Both species are distinguished by their size from the present specimen. The dimensions of the specimen are as follows:—

| | | | |
|---|---|---|---|
| Length of jaw (broken) ... .. | 3·5 | Thickness .. .. .. | ·5 |
| Depth .. .. .. .. | ·8 | Length of alveolus of canine .. | ·75 |

### AMPHICYON PALÆINDICUS, *nobis.*

The only remains of this species hitherto known are an upper tubercular molar, and a lower carnassial, one from Kushalghar, and the other from Nurpur. These specimens are figured on Pl. 7 of "Indian Tertiary and Post-Tertiary Vertebrata."* Mr. Blanford has sent from Sind the anterior half of a right lower carnassial, which exactly corresponds with the Nurpur specimen, and which shows that the species extended its range into the Sind area.

* Palæontologia Indica, Ser. X—2, Vol. I—2.

## NOTE ON THE ARVALI SERIES IN NORTH-EASTERN RAJPUTANA, *by* C. A. HACKET, *Geological Survey of India.*

The rocks that have been named the Arvali Series cover a large area in Rajputana. The portion of them which has been examined, and of which the following is a brief description, lies in the territories of the Rajahs of Alwar, Jaipur, Bhartpur and Karauli, included between Bhartpur on the east and Jaipur on the west, the northern boundary of the Alwar territory on the north, and a line drawn in a south-westerly direction from Byana through Karauli to the fort of Rimtumbour on the south.

This area is occupied by ranges of hills, the highest of which rise to an elevation of upwards of 2,500 feet above the level of the sea, and about 1,600 feet above the general level of the surrounding country formed of wide sandy alluvial plains. Some of these hills are narrow ridges; others form considerable masses, occasionally flat-topped, presenting arid, stony plateaux several square miles in extent. The principal of these hill-groups are those of Alwar, Byana, Lalsot and Rimtumbour.

The Alwar hills are in places twenty miles across; they are, however, intersected by narrow longitudinal valleys having the same general direction as the hills themselves; both, in fact, following the strike of the rocks.

The direction of the ranges varies considerably; the most general direction is north to south and north-east to south-west, but in places the ridges describe a complete semicircle.

The principal rivers draining this area are the Moril, Banas, Sabi and Banganga. The two former fall into the Chambal near Rimtumbour, and the two latter into the Jumna, one near Delhi and the other below Agra. Their broad, shallow sandy beds, sometimes upwards of a mile wide, contain little or no water, except in the rains.

In the accompanying map, on account of its small scale, the hill-shading has been omitted.

Besides the Arvali series, there are in our area a gneiss and a schist series, the Gwalior and the Vindhyan series.

The gneiss is confined to a few small isolated hills on the plain, and some outcrops at the base of the scarps of the Arvali rocks on both sides of the Banganga valley; but in the latter position it is very imperfectly seen, as it is mostly covered by the debris of the overlying rocks.

The schist series is exposed in several places in the Byana hills and at Malarna near the Moril river. In the Byana hills at Nithahar, the schists consist of alternations of mica-schists and thin bands of quartzites; they are nearly vertical, and are overlaid unconformably by the rocks of the Arvali series.

Both the Gwalior and the Vindhyan series have already been described, the former in the Records and the latter in the Memoirs of the Survey.

The Gwalior series is represented in our area in the ridge at Hindun, extending in a north-east to south-west direction, and formed of banded red jasper alternating with bands of hæmatite.

The Vindhyan series is represented by a few outlying hills which occur west of a line of fault forming the north-western boundary of the main basin of the series.

Arvali series.

The rocks of the Arvali series are much disturbed, seldom dipping at a lower angle than 70°; their most general strike varies from north—south to north-east—south-west; but in places they describe nearly three-fourths of a circle. In the Alwar territory, where more extensive and continuous sections are exposed than elsewhere within our area, the rocks are folded up and repeated many times; thus, a short distance north of the Banganga river the same beds are repeated at least a dozen times in a section sixty miles long. The rocks have undergone a considerable amount of metamorphism, some of the quartzites being compact and vitreous, the limestones highly crystallised and full of minerals, such as shorl, actinolite, tremolite, &c., and the schists and slates highly mineralised, containing an abundance of crystals of andalusite, staurotide, garnets, &c. An arkose rock, or pseudo-gneiss, locally forming the base of the series, is often so highly metamorphosed as to render it difficult, in places where good junction-sections are not exposed, to tell it from the older gneiss upon which it rests.

A great variety of rocks is included in the series, the principal of which are quartzites, dolomitic limestone, contemporaneous trap, hornstone-breccia, schists and slates.

These have been grouped in the following manner, in descending order:—

Mandan—slates, schists, quartzites.
Ajabgarh—slates, quartzites, hornstone-breccia, limestone.
Alwar—quartzite, conglomerate, schists, limestone, bedded trap.

The Alwar group has been sub-divided in descending order into—

Alwar group.

Alwar quartzites, including irregular bands of schists, conglomerate and contemporaneous trap,
Raialo limestone,
" quartzite.

The lowest beds, the Raialo quartzite and limestone, are only seen near the southern extremity of the Alwar hills north of the Banganga river. In the three bays of Andhi, Bhangarh and Baswa, the quartzite, compact in texture, regularly bedded, and grey in color, rests upon the gneiss and dips under the limestone.

The limestone is highly crystallised and dolomitic, and abounds in tremolite, shorl and actinolite; it is often pure white, but marbles of a great variety of color and also of texture can be obtained. There are large spreads of the limestone at Raialo and Baldeogarh and at Kho; in other places, as west of Andhi and in the Baswa bay, the thickness is considerably less. No good sections of the junction between the Raialo quartzites and the gneiss are exposed, although the two are often seen within a few yards of each other; the actual junctions are all covered by the debris.

Both the Raialo quartzite and limestone are locally overlapped by the next higher member of the group, the Alwar quartzite, which then rests directly on the gneiss. A few good sections of the junctions are exposed, which shew that the Arvali series is quite unconformable to the gneiss. The Alwar quartzite is the most prominent member of the whole series, both from the extent of ground it covers, and from the highest and largest groups of hills being formed of it; also from the principal forts in the neighbourhood, those of Byana, Alwar and Rimtumbour being built on it.

The thickness of the Alwar quartzites varies considerably in different sections; thus, in the Byana hills an enormous thickness of them is exposed in an unbroken section upwards of five miles long in which the rocks have a steady dip to the north of about 20°; but about Nithahar the lower beds die out and the quartzites are reduced to a few hundred feet. In the Lalsot hills, where the rocks dip at a much higher angle, the quartzites are in force. In the Alwar hills, too, there is in places a great thickness, but they thin out to a few hundred feet in a southerly direction.

The quartzites are mostly light grey in color, regularly bedded and compact in texture, although coarser beds are of frequent occurrence. They also include, especially in the

Byana hills, thick bands of conglomerate. Ripple-markings and sun-cracks are common and are particularly well seen in the Alwar fort hill. An arkose is of frequent occurrence at the base of the Alwar quartzites, where they rest upon the gneiss.

The best section of the junction of the Alwar quartzites and the gneiss is exposed near Tatra. South of the road leading to Tatra the granitic gneiss occurs at the base of the ridge, and upon this rests a regularly bedded coarse quartzite dipping at a high angle to the west. North of the road some additional beds come in between the gneiss and the quartzites. Resting directly on the gneiss is a band of conglomerate about two feet thick, composed principally of rolled pebbles of quartz; upon this there is a considerable thickness of the arkose, the materials of which were apparently derived from the gneiss; this passes up gradually into the ordinary quartzites of the series. Other sections shewing the unconformity between the two series are exposed near Garhi a few miles east of Tatra, and near the southern end of the Tatra ridge at Sabraoli, as well as in the Lalsot hills at Geesgarh.

In places the arkose rock has been re-metamorphosed to such an extent that when not seen in connection with the gneiss below, or the quartzites above, it is difficult to tell it from the true gneiss. Instances of this occur in the hills round Harsora, which are formed of obscurely bedded gneiss, but from their being isolated on the plain (the only rock near is a ridge of quartzite about half a mile to the south) I am unable to say to which series they belong. At Dodikar, a few miles north-west of the town of Alwar, where the arkose rocks are well developed, they form a circle of hills, in the centre of which the rocks are covered by the alluvium, blown sand, &c. The arkose at the base of the hills is highly crystalline and as gneissose as that of the Harsora hills, but here they pass up gradually into the quartzites which cover them. Other sections of the arkose rocks passing into the quartzites are met with at Palpar, Baggeri, Khertal and Pahari.

The best sections of the Alwar quartzite are to be seen in the Byana hills, where an enormous thickness of them is exposed, as they are less disturbed and altered than elsewhere, for although they are a good deal twisted along the strike, they scarcely ever dip at a higher angle than 20°. At Byana the strike is north-east to south-west; but at Badalgarh, a short distance west, it changes to west-north-west, east-south-east; and at Hathoree, about twelve miles further west, it again becomes north-east to south-west.

In these hills the lowest members of the Alwar group (the Raialo quartzite and limestone) are absent, and the group consists principally of quartzites, shales, thick bands of conglomerate, and contemporaneous trap. Overlap occurs among the quartzites, and there are two cases of local unconformity.

The Alwar group in the Byana hills rests unconformably upon the schist series. The unconformity can be well seen at Nithahar, where the quartzites rest upon the edges of the nearly vertical schists, consisting of alternations of argillaceous and quartz schists, and with a thin band of conglomerate seldom more than a foot thick between them. Other sections of the unconformity are exposed a few miles further west.

The Alwar quartzites in these hills can be divided into several sub-groups well marked by overlap or local unconformity:

Weir—quartzites and black slatey shales.
Damdama—quartzites and conglomerate.
Byana—white quartzite and conglomerate.
Badalgarh—quartzite and shale.
Nithahar—quartzites and bedded trap.

The middle sub-groups attain to an enormous thickness at the eastern end of the hills, but die out near Hathoree. At the western end, a few miles south-west of Nithahar, all the lower sub-groups are overlapped by the highest, which then rests upon the schists. The lowest of these sub-groups, the Nithahar, consists of upwards of 2,000 feet of quartzites, including several bands of contemporaneous trap. The next sub-group, the Badalgarh, consists of about 800 feet of shales and quartzite, best seen in the Badalgarh fort hill, but west of this it gradually thins and dies out near Seta.

The Byana sub-group is formed of a white quartzite containing many bands of conglomerate. It extends from Byana some miles west, but dies out three or four miles east of Seta. These conglomerate bands are well seen in the hills near Byana. They vary in thickness from 1 to 20 feet, divided by thin bands of quartzite. They are made up of pebbles of quartzite, very similar to those of the lower sub-groups. All of the conglomerate bands die out within a quarter of a mile of Byana. Above the Byana comes the Damdama sub-group, composed of an enormous thickness of conglomerate and quartzite. The conglomerate is made up of pebbles of quartzite. jasper, and white quartz, all more or less water-worn. Like the other sub-groups, this thins out very rapidly. At Hathoree, where the strike of the rocks suddenly changes, it is reduced to a few feet; it expands again a short distance further south-west, but is eventually overlapped a few miles south of Nithahar by the highest sub-group, the Weir.

In a gorge about one and a half miles east of Seta, the Damdama sub-group for a short distance rests upon a denuded surface of the Badalgarh sub-group; further west the latter sub-group dies out and the Damdama rests unconformably on the Nithahar sub-group. These unconformities appear to be local, for to the east of Seta, where good sections of the junctions of the different sub-groups are exposed, no trace of unconformity could be detected.

The highest sub-group, the Weir, consists of black slaty shales, and a great thickness of quartzites. It occupies the broken east and west ridge a short distance north of the Byana hills. At Hathoree the strike changes to south-west, and at two or three miles south-west of Nithahar it overlaps all the other sub-groups and rests upon the schists. This ridge of Weirs continues in a south-west direction and connects the Byana with the Lalsot hills, where there is again an enormous thickness of the Alwar quartzites in which presumably all the sub-groups are represented, but are not distinguishable, as all the conglomerates have disappeared. In the Alwar hills, too, these sub-groups cannot be traced, although there is an equally great thickness of the quartzites, including several thin bands of conglomerate, but which are very irregular, continuing only a short distance along the strike.

The Arvalis along their south-eastern boundary, between Karauli and the Banas river, form two synclinals in which both the Alwar quartzites and the lower portion of the Ajabgarh groups are exposed. South-west of the Banas a considerable thickness of the Alwar quartzites, including two or three bands of trap, is seen in a shallow synclinal in the Rimtumbour hills.

This boundary of the Arvalis is formed by a fault, on the south-eastern side of which the top group of the Vindhyans is brought against the Alwar quartzites. In the two synclinals between Karauli aud the Banas river, on the north-west side of the fault, are several ranges and hills formed of shales and sandstone, probably the representatives of lower members of the Vindhyan series.

Ajabgarh group.

The rocks of this group occur chiefly in the Alwar hills; but a small thickness of them is also exposed in the Rimtumbour hills. In the Alwar hills they occupy the synclinal trough in the quartzites of the Alwar group, they also form the ridges to the east of the town of Alwar. The group contains a considerable thickness and a great variety of rocks, the principal of which are limestone, quartzites, hornstone-breccia, and slates.

*The lowest member of the group is a thick band of limestone called the Kushalgarh limestone. It is generally compact in texture, dark and light blue in color, the two shades arranged in alternate bands, and frequently contains an abundance of schorl, actinolite, and tremolite.* The hornstone-breccia is generally found on the top of the Kushalgarh limestone, but is frequently absent. Above this there is a band of quartzite, upon which rests a considerable thickness of black slates frequently containing garnets and andalusite, capped by a quartzite, the Berla quartzite.

So far the section of the Ajabgarh group is continuous in the valleys; but the upper rocks, being only exposed in the isolated ridges east of Alwar, are difficult to place in the section. The ridge extending from the Motidongri hill, close to Alwar, composed of alternations of calcareous and quartzite bands, is clearly higher in the section than the Berla quartzite; and the Goleta ridge, about six miles east of Alwar, is probably still higher in the section.

The best sections of the lowest beds of this group are exposed in the Kushalgarh and Ajabgarh valleys. In the former, from the town of Kushalgarh to the mouth of the valley at Talbrich, the whole of the bottom of the valley, in places upwards of a mile wide, is occupied by the Kushalgarh limestone. Higher up the valley, rocks higher in the section come in. Both the breccia and quartzite are poorly represented, but the black slates are well developed and include thin and irregular bands of limestone as well as one or two bands of hornblende rock.

A thicker section of the Ajabgarh group is exposed in the Ajabgarh valley. The Kushalgarh limestone resting upon the Alwar quartzites is seen on both sides, dipping towards the centre of the valley, though not so continuously on the west as on the east side. The hornstone-breccia and the quartzites above appear to be very irregularly developed in this valley. The breccia is nearly continuous on the west side, and there is but little of the quartzite, but on the east side, particularly at the northern end, a considerable thickness of the quartzites, but little of the breccia, is seen. The whole of the centre of the valley is occupied by the black slates. These rocks extend into the Narainpur valley as far as Gazeka Thana; but north of that there are only a few small hills of slates in the centre, and some of the limestone and breccia on either side of the valley. The remainder is covered by the alluvium.

In the Delawas valley, patches of the Kushalgarh limestone are exposed on both sides of the valley; the higher rocks occupying the centre are covered by the alluvium. Near Sillisur, about four miles south-west of Alwar, the hornstone-breccia above the limestone is exposed. It is in some places obscurely bedded, but it generally occurs in great masses devoid of any structure. It sometimes contains large pebbles of quartzite; this is the case at the southern end of the Sillisur lake, where it is largely developed.

The eastern edge of the Alwar quartzites at Alwar, and for a long way south, dips at an angle of about 80° to the east under a broken section of the Ajabgarh group, here represented by a few hillocks of the Kushalgarh limestone and breccia and the overlying quartzites. The slates are entirely covered by the alluvium which extends to the Motidongri ridge, formed of nearly the highest member of the group.

Of the ridges to the east of the Motidongri ridge many are formed of the rocks of the Ajabgarh group. Thus, in the hills forming a broken circle a few miles east of Alwar, in the centre there is a hill of the Alwar quartzites dipping in all directions towards the edge of the circle and under the encircling ridge of the Ajabgarh rocks consisting, on the eastern side, of the black quartzites and slates in which crystals of andalusite are abundant. The rocks on the western side are higher in the section. At Loharwarri there is a black limestone, probably the same as that in the Motidongri ridge, and over it a considerable thickness of a rough blue quartzite, largely quarried for grindstones. Between the centre hill and the ridge are some hillocks formed of the Kushalgarh limestone and breccia.

The four ridges east of Malakheri, something in the shape of an inverted W, form a double anticlinal in which the Ajabgarh rocks are well represented. In the centre of the western anticlinal there is a large hill of the Alwar quartzites dipping under the Kushalgarh limestone and breccia on three sides, *viz.*, north, east, and west, above which come the black slates with a band of talcose limestone near the base and covered by the Berla quartzite, of which the greater portion of the four ridges is formed. This quartzite requires notice, as it makes a splendid building stone and is largely quarried for that purpose; it is pearly-grey in color and contains numerous specks of a black mineral, probably hornblende. In the eastern anticlinal a similar section is exposed, with the exception of the Alwar quartzites in the centre. The western limb of the double anticlinal extends in a northerly direction as far as Noganwa, where the Alwar quartzites of the Tigara ridge dip under it; and in a south-westerly direction, to some miles beyond the Deoti lake in a synclinal trough of the Alwar quartzites.

The Mándán group.

The rocks of this group occur only in the Alwar territory, principally in the north-west corner of the State, on the left bank of the Sahi river at Mándán Barod and Tasing, and at Mandaor, thirty miles to the south-east of Alwar. The group consists of schists and slates, abounding in crystals of andalusite, staurotide, garnets and actinolite, and some thin bands of quartzite interbedded with them.

There is some doubt as to the position of these rocks in the series, or even if they belong to the series at all. This doubt arises from their occurring in isolated ridges disconnected from any known rock of the series. Near Barod, however, there is a long hill formed of the Kushalgarh limestone and breccia, between two ridges of the schists, and separated from them by about half a mile of alluvium.

Again, at Mandaor, the double ridge of Mándán schists occurs between two ridges of Alwar quartzites, converging towards the south and both dipping towards the schists, apparently forming a synclinal in which the schists lie. Mineralogically there is little difference between the Mándán rocks and those of the known Arvali series; the Ajabgarh slates containing andalusite, &c., in the hill east of Alwar, as well as the quartzites, are very similar to those of the Mándán group; so that it seems probable that the Mándán rocks really belong to the series, and if so they form the highest group here represented.

Trap.

The lower part of the Alwar quartzites contains numerous bands of contemporaneous trap, some of them of considerable thickness and forming hills several hundred feet high. In some sections they are very numerous, while in others they are altogether absent. In the Byana hills there are at least six bands separated by bands of quartzite. At the southern part of the Alwar hills, for some miles round Tehla and north of Raialo, they are also very numerous. In the Tehla section there are at least ten separate bands. Again, in the Rimtumbour hills the quartzites include several bands of trap, one of which is upwards of 150 feet thick. In the northern part of the Alwar hills a comparatively thin band of trap is occasionally met with, but generally it is altogether absent. In the large accumulations of quartzites in the hills west of Rajgarh, and also in the Lalsot hills, there is no trap in the section.

Many of these bands of trap can be traced for several miles; this is particularly the case with those west and north-west of Raialo, and also in the Rimtumbour hills; but in other places, as near Tehla, they often die out very suddenly. Occurring on nearly the same geological horizon as these traps are some bands of hornblende rock, which are probably of metamorphic origin.

Relations of Arvalis to other formations.

The position of the Arvali series in the scale of Indian formations is somewhat doubtful. I have already stated that it rests unconformably upon the gneiss and the schists, and that outlying ridges and hills probably belonging to the Vindhyan series rest upon it. The doubtful point then, is the relative position of the Gwalior and the Arvali series.

The Gwalior series is most largely developed in the neighbourhood of Gwalior, where it rests unconformably upon the gneiss of Bundelkhand, and is covered, also unconformably, by the Vindhyans. The series there consists of a quartzite-sandstone at base, covered by many hundred feet of banded jasper, including several bands of limestone and contemporaneous trap. The rocks of the series are only slightly disturbed, seldom dipping at a higher angle than 5°, and are much less altered than the Arvali series in Rajputana.

The only representative of the Gwalior series within our area is a long broken ridge of banded jasper rocks dipping at an angle of between 60° and 80° to north-west near Hindon. The ridge runs in a north-east to south-west direction parallel to, and at a varying distance of 200 yards to two or three miles from, the north-west boundary of the main area of the Vindhyan series. The north-eastern extremity of this ridge extends to within three miles of the south-eastern end of the Byana hills formed of the Arvali series.

The only rocks seen in contact with the banded jasper of the Gwalior ridge at Hindon are some hills of quartzite sandstone associated with some red and black slaty shales and irregular bands of limestone. The quartzite sandstone is in places highly altered; but in others it shews scarcely any traces of alteration. It is nearly vertical, and the strike is roughly parallel to that of the banded jasper. All the junctions ars concealed by debris; but the quartzite appears to rest upon different beds of the jasper rock; thus at the northern end of the ridge the quartzites are on the southern side, but further south they cross the ridge and are on the north-west side of it. From the position of these hills of quartzite sandstone, and from their being generally less altered than the rocks of the Arvali series, it seems probable that they are outliers of the Vindhyan series. On the other hand, the black and red slaty shales and limestone are unknown in the lowest beds of the Vindhyans; but somewhat similar beds occur in the quartzites of the Arvalis.

The only other evidence bearing upon this point is the presence of some jasper pebbles in the conglomerate beds of the Arvali series; but although these resemble the Gwalior jaspers, they are not sufficiently characteristic to determine the point. The question is one of much geological interest; it would greatly complicate matters to have to make the Arvalis younger than the Gwaliors.

Economic geology.

The useful minerals found within our area are—copper pyrites, rutile, argentiferous galena, manganese nickel, iron.

Several old copper workings exist, from which through a long series of years a considerable amount of ore has been extracted, but at the present time they are almost entirely abandoned. The natives say that some of the richest deposits of ore had to be abandoned in consequence of the influx of water. In other cases, the richest mines fell together, burying a number of miners, and have not since been re-opened.

The following is a list of the localities in which copper ore has been worked or traces of it observed:—

| | |
|---|---|
| Daribo. | Baghani. |
| In the ridge to the west. | Pertabgarh. |
| Indawas. | North of Nitahar. |
| Bhangarh. | Near Garh in the Lalsot hills. |
| Tasing. | Lalsot. |
| Kushalgarh. | Nabaro. |

The most important of these is Daribo in the Alwar territory. The mine is situate on a sharp anticlinal bend, in a thin band of black slates intercalated in the Alwar quartzites. Formerly the workings consisted of some small pits on the hill-side. Dr. Impey, then Political Agent at Alwar, had a long adit level driven into the hill to drain these pits. The level runs in a southerly direction parallel to the strike of the rocks. I could see no trace of a lode; the ore appears to be irregularly disseminated through the black slates, a few specks and stains only being seen in the quartzites. Where richer nests of ore were met with, the miners have extended their workings a short distance above or below the level. They state that a rich nest of ore occurs in a pit sunk below the level near its southern extremity, but that it had to be abandoned on account of the water.

The copper occurs in the form of pyrites mixed with arsenical iron. Small quantities of carbonate of copper were observed in the mine, probably the result of the decomposition of the sulphuret. The mine is now nearly abandoned, and but little ore is to be seen; I had some difficulty in finding a piece the size of a hazel-nut. I found traces of copper in some black slates on the same geological horizon in the ridge a short distance west of Daribo.

Near Indawas there is a long open cutting from 20 to 30 feet deep, from which copper ore has been extracted, but the workings are now filled with water. About a mile from these workings I found some miners engaged in sinking a small pit in the Kushalgarh limestone, from which they got a little ore. The Bhangarh workings consist of two or three small pits now fallen together. I found traces of copper in the Mándán schists near Tasing.

The workings at Kushalgarh, Baghani, and Pertabgarh have been abandoned for many years. The natives say that at the two latter places the workings were very extensive, and that the mines fell together suddenly, burying a large number of men. The workings near Nitahar, at Garh, Lalsot and Nabaro are very small, and have long since been abandoned.

A few years ago a small deposit of silver-lead ore was discovered in the Kushalgarh limestone near Gudha, and a pit was sunk in it; but after working for a short time it was found that the ore died out in every direction. The pit has now fallen together.

Rutile (titanic acid) exists in small quantities in some little quartz veins in the Motidongri ridge a short distance south of Alwar.

Iron and Manganese.

Iron ore occurs in large quantities at two places near the base of the Arvali series, one near Bhangarh and the other near Rajgarh. They supply the ore to a large number of furnaces in the State. Judging from the workings, an immense quantity of iron must have been produced from these mines. These excavations are several hundred yards long and, in places, 20 to 30 wide. They appear to be at an angle to the strike of the beds; but the rocks are so disturbed, and the junctions covered by debris, that I was not able to determine the point. The following is an analysis of the ore from Bhangarh: A mixture of limonite and magnetite and oxide of manganese, containing 59·67 per cent. of iron, and 12·7 of manganese. Large quantities of a superior iron ore have been raised from the Gwalior rocks in the ridge near Hindun.

Nickel.

When making inquiries for the mineral Saipurite (Jaipurite), a mineral of cobalt found in the Arvali series at the Ketree mines in Shekawattee, I was shewn a bit of iron and the ore from which it had been produced. The iron was used for cannon balls which flew into a number of fragments when fired. The ore came from the Bhangarh mine. On analysis both the iron and the ore were found to contain nickel, in the latter, however, only a trace. I tried to find the ore in site, but was not successful. I was shown the pit from which it had been taken, but it had fallen in.

Building materials.

Building materials, some of a very superior quality, are abundant. Limestone capable of making good lime exists in all parts of the Alwar hills, as well as in Karauli and on the Banas river.

The ordinary quartzite is a useful stone for rough buildings, walls, &c. But the Berla quartzite makes an excellent building stone. It is pearly-grey in color, very durable, not difficult to work and, easily quarried. It is largely quarried at Berla, Daroli, Bharkhol, &c.; and quarries of it could be opened in any part of the four ridges east of Malakheri. A large part of the Rajah's private station at Alwar is built of this stone.

Schistose quartzites used for roofing, flags, &c., are largely quarried near Rajgarh, Kirwari, Mándán, and north of Amber. I have seen slabs of this rock nearly 20 feet long and 2 feet wide. The Mándán rock produces large, square, thin slabs.

Finely laminated argillaceous flags, splitting easily along the laminæ, are procured from some quarries at Salimpur at the end of the Alipur ridge near the Banganga river. Slabs of large size, and of any thickness down to half an inch, are quarried. The stone contains a good deal of iron pyrites, which discolors it when exposed to the weather.

The Ajabgarh slates have been used for roofing most of the stations on the railway. It is not quarried, that I know of, within our area, but some of the hills in the Ajabgarh valley would, I think, produce equally good slates.

A talcose limestone at the base of the black slates is used for ornamental purposes, such as carved door-posts, &c. It is a soft stone and easily carved.

The Raialo group produces fine marble. The Taj at Agra is, I believe, built of it. It is quarried at Raialo and Jheri; and the natives there are still very clever in making *jalee* or perforated screens. Colored marbles can be had near Kho and Baldeogarh, and black marble from the Motidongri ridge.

Good mill-stones are made from the blue quartzites of the Goleta ridge.

## BORINGS FOR COAL IN INDIA, *by* THEODORE W. H. HUGHES, F. G. S., *Associate, Royal School of Mines. Geological Survey of India.*

The purpose of the present paper is to introduce a series of notices on borings for coal throughout India, which, it is hoped, will possess some interest and, possibly, be of practical utility to those whose duties are connected with this branch of mining engineering. The advantage of having in an accessible form, for purposes of comparison, statistics from different localities as to method of boring, progress of boring, cost of boring, &c., will, I trust, be appreciated by those interested in this matter, and in time acknowledged by a greater readiness on the part of individuals and associations to supply information than has as yet been evinced. Up to the present I am unable to quote beyond the experiences at the Government borings. Such as they are, they are here offered as measures of comparison.

breadth as the cutting edge. By adopting this plan of shaping, instead of allowing the smith to diminish the width of the tool throughout the length indicated, a smooth hole can be made at the same time that the chisel is advancing. For boring through stiff clays, an S chisel is a convenient form, as it penetrates less, if the drop be carelessly increased, than does the straight bit, and consequently is not so likely to stick. The auger is preferred by some.

Respecting the question, which is the most efficient pattern of tool for a given kind of work, I have remarked that a good deal depends upon the predilection of the workmen, and that the best results are attained by adhering to the form of chisel they have been first accustomed to handle. For general usefulness, however, there is little doubt that the straight bit claims pre-eminence. For stiff clays, I would recommend the Schisel, and for soft clays the auger. In moderately free sandstones and shales, the S chisel will do excellent work, and it may be used as a substitute for the straight bit. In the ordinary grits of the coal-measures it fails to make the same amount of way.

Cleaning tools.

To clean the hole, a pump or sludger provided with an ordinary flap-valve, or else a ball-valve, was employed. It possesses an advantage over the wimble and other revolving tools used for clearing, in that it may be lowered and raised by means of a rope, and the time occupied in connecting and disconnecting the rods is saved. The ball-valve is a very simple and convenient form of valve to adopt, as it does not get out of order, but the balance of general opinion is, I believe, in favor of the ordinary flap-valve.

Piping.

For most of the bore holes, only a few lengths of piping besides the guide tube were required. When the fear of any clay swelling arose, it was found well to push operations on without cessation, and to work night, as well as day, shifts. This usually obviated the necessity for lining. The most intractable rock was running sandstone, and experience proved that when the difficulty of keeping a hole was due to this cause, it was an economy of time and labor to shift to a fresh position if piping were not available.

Rate of progress.

The rate of progress varied according to the rocks to be bored through, trap being the most refractory and ordinary felspathic silicious sandstone the most easy to deal with. In a scale of tractability they stand in the following order—a wide difference of degree separating trap and ironstone from the rest:—

1. Trap.
2. Ironstone.
3. Vitreous quartzose sandstone.
4. Clay.
5. Coal.
6. Shale.
7. Ordinary sandstones.

Below will be found in tabular form the speed at which some of the holes in the Wardha Valley were put down, and the cost of cooly-labor divided over each foot or yard. There were usually three shifts of workmen in the 24 hours when the holes were being continuously pushed forward. Each shift consisted of twelve coolies and two mates or brace-head men as a rule, but sometimes an additional couple were put on, if the hole was a troublesome one, making sixteen men in all. The pay of the coolies was 4 annas a day, the pay of the mates 5 annas. An overseer on Rs. 25 to 35 a month looked after one and sometimes two bore holes.

The returns that I quote are those furnished to me by Mr. Ness and by Mr. Smyth. Each has adopted a form which I publish as received.

*Statement of cost of bore holes at Warora for each 10 yards in depth.—Wardha Valley Coal-field.*

| | Depth of hole. | Number of days' boring. | Cost per yard of 1st 10 yards. | 2nd 10 yards. | 3rd 10 yards. | 4th 10 yards. | 5th 10 yards. | 6th 10 yards. | 7th 10 yards. | 8th 10 yards. | 9th 10 yards. | 10th 10 yards. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Rs. A. P. | Rs. A. P. | Rs. A. P. | Rs. A. P. | Rs. A. P. | Rs. A. P. | Rs. A. P. | Rs. A. P. | Rs. A. P. | Rs. A. P. |
| Bore hole O[1] ... | 110' | 5 | 0 12 9 | 1 9 6 | 2 6 3 | 3 3 0 | ... | ... | ... | ... | ... | ... |
| " " P[1] ... | 115' | 4 | 0 14 11 | 1 13 10 | 2 12 9 | 3 11 8 | ... | ... | ... | ... | ... | ... |
| " " R[1] ... | 176' | 9 | 0 12 1 | 1 8 2 | 2 4 3 | 3 0 4 | 3 12 5 | 4 8 6 | ... | ... | ... | ... |
| " " S[1] ... | 152' | 9 | 0 12 7 | 1 9 2 | 2 5 9 | 3 2 4 | 3 14 11 | 5 8 1 | ... | ... | ... | ... |
| " " T[1] ... | 149' | 6 | 0 9 4 | 1 2 8 | 1 12 0 | 2 5 4 | 2 14 8 | ... | ... | ... | ... | ... |
| " " U[1] ... | 336' | 51 | 1 1 3 | 2 2 6 | 3 3 9 | 4 5 0 | 5 6 3 | 6 7 6 | 7 8 9 | 8 10 0 | 9 11 3 | 10 12 6 |
| " " W[1] ... | 253' | 20 | 0 12 5 | 1 8 10 | 2 5 3 | 3 1 8 | 3 14 1 | 4 8 6 | 5 4 11 | 6 1 4 | 6 13 9 | ... |

W. NESS,
*Mining Engineer.*

## *Return shewing rate of progress and cost of bore holes in the Wún District of the Wardha Valley Coal-field.*

| Name of bore hole. | Total depth of bore hole. | | Total number of days taken. | Total number of days boring 1st 100 feet. | Total number of days boring 2nd 100 feet. | Total number of days boring 3rd 100 feet. | Total number of days boring 4th 100 feet. | Average depth bored per day. | | Average depth bored per day for 1st 100 feet. | | Average depth bored per day for 2nd 100 feet. | | Average depth bored per day for 3rd 100 feet. | | Average depth bored per day for 4th 100 feet. | | Total cost of each bore hole. | | | Average cost per foot for 1st 100 feet. | | | Average cost per foot for 2nd 100 feet. | | | Average cost per foot for 3rd 100 feet. | | | Average cost per foot for 4th 100 feet. | | | Average cost per foot for total depth. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ft. | In. | Days | Days. | Days. | Days. | Days. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Rs | As. | P. | Rs. | As. | P. | Rs. | A. | P. | Rs. | A. | P. | Rs. | A. | P. | Rs. | A. | P. |
| Papur, No. 1 ... ... | 110 | ... | 12 | 10½ | 1½ | ... | ... | 9 | 2 | 9 | 6 | 6 | 6 | ... | ... | ... | ... | 99 | 12 | 0 | 0 | 14 | 3·4 | 1 | 10 | 0·7 | ... | ... | ... | ... | ... | ... | 0 | 14 | 6·1 |
| Pisgaon, No. 7 ... ... | 129 | ... | 4 | 2½ | 1½ | ... | ... | 32 | 3 | 40 | 0 | 19 | 4 | ... | ... | ... | ... | 57 | 0 | 0 | 0 | 5 | 8·4 | 1 | 7 | 7 | ... | ... | ... | ... | ... | ... | 0 | 7 | 0·8 |
| Pisgaon, No. 9 ... ... | 333 | ... | 43 | 5 | 12 | 20 | 6 | 7 | 8·9 | 20 | 0 | 8 | 4 | 5 | 0 | 5 | 6 | 419 | 4 | 0 | 0 | 6 | 9·6 | 1 | 2 | 8·6 | 1 | 15 | 2·4 | 2 | 5 | 6·1 | 1 | 4 | 1·7 |
| Pisgaon, No. 11 ... ... | 155 | ... | 13 | 5 | 8 | ... | ... | 11 | 11 | 20 | 0 | 6 | 8 | .. | ... | ... | ... | 185 | 4 | 0 | 0 | 11 | 4·8 | 2 | 15 | 1·4 | ... | ... | ... | ... | ... | ... | 1 | 3 | 1·4 |
| Warura, No. 1 ... ... | 231 | ... | 28 | 6 | 14 | 8 | ... | 8 | 3 | 16 | 8 | 7 | 1·7 | 3 | 10½ | ... | ... | 399 | 0 | 0 | 0 | 13 | 8·1 | 1 | 15 | 11 | 2 | 8 | 5·4 | 0 | ... | ... | 1 | 11 | 7·6 |
| Warura, No. 2 ... ... | 162 | ... | 11 | 6 | 5 | ... | ... | 14 | 8·7 | 16 | 8 | 12 | 4·8 | ... | ... | ... | ... | 156 | 12 | 0 | 0 | 13 | 8·1 | 2 | 5 | 4·4 | ... | ... | ... | 0 | 0 | ... | 0 | 15 | 5·7 |
| Warura, No. 3A ... ... | 158 | ... | 16 | 10 | 6 | ... | ... | 9 | 11·1 | 10 | 0 | 9 | 9·8 | ... | ... | ... | ... | 228 | 0 | 0 | 0 | 4 | 2·6 | 2 | 15 | 1·9 | ... | ... | ... | 0 | 0 | ... | 1 | 5 | 2 |
| Wún ... ... ... | 310 | 10 | 42 | 5 | 8 | 26 | 3 | 7 | 4·8 | 20 | 0 | 12 | 9·6 | 3 | 10·1 | 3 | 7·3 | 470 | 4 | 0 | 0 | 9 | 1·4 | 0 | 13 | 7·2 | 2 | 15 | 10·4 | 2 | 2 | 8·4 | 1 | 8 | 0·8 |

R. BATEMAN SMYTH,
*Offg. Supdt. Pisgaon Coal Mines.*

*15th May* 1875.

In the statement of expenses made by Mr. Ness there is a regular augmentation in the price of labor for every additional ten yards, equal to the cost of the first ten. Mr. Smyth has entered more into details, and thus rendered his returns more useful and more interesting. There is no regular rate of increase in the charges.

The deepest hole (that of Pisgaon No. 9) 333 feet in depth, occupied only 43 days, and was put down at an average speed of 20 feet a day for the *first* 100 feet, 8 feet 4 inches a day for the *second* 100 feet, 5 feet a day for the *third* 100 feet, and 5 feet 6 inches for the portion of the *fourth* 100 feet. This is a rate of progress which, I think, must be admitted to be satisfactory. The rocks are principally sandstone, but there are some bands of clay, and these reduced the averages of speed considerably. The following is the section of the strata passed through:—

*Pisgaon—No. 9.* W(ʻN DISTRICT.

| | Ft. | In. |
|---|---|---|
| 1. Surface soil | 5 | 0 |
| 2. Sandstone, yellow | 12 | 0 |
| 3. Ditto, red | 1 | 0 |
| 4. Ditto, yellow | 15 | 0 |
| 5. Ditto, red | 6 | 0 |
| 6. Ditto, reddish-yellow | 10 | 0 |
| 7. Ditto, yellow | 9 | 0 |
| 8. Ditto, red | 17 | 0 |
| 9. Ditto, yellow | 2 | 0 |
| 10. Ditto, reddish-yellow | 3 | 0 |
| 11. Ditto, red | 14 | 0 |
| 12. Ditto, yellow | 1 | 0 |
| 13. Ditto, red | 6 | 0 |
| 14. Ditto, yellow | 2 | 0 |
| 15. Ditto, red | 2 | 0 |
| 16. *Clay*, red | 7 | 0 |
| 17. Sandstone, red | 10 | 0 |
| 18. Ditto, yellow | 9 | 0 |
| 19. Ditto, red | 4 | 0 |
| 20. Ditto, yellow | 4 | 0 |
| 21. Ditto, red | 7 | 0 |
| 22. Ditto, yellow | 7 | 0 |
| 23. Ditto, red | 3 | 0 |
| 24. Ditto, yellow | 34 | 0 |
| 25. Black carbonaceous earth | 2 | 0 |
| 26. *Clay* | 9 | 0 |
| 27. Sandstone, white | 22 | 0 |
| 28. *Clay*, blue | 4 | 0 |
| 29. Sandstone, white | 33 | 0 |
| 30. Clay, blue | 8 | 0 |
| 31. Sandstone, white | 40 | 0 |
| 32. Clay | 2 | 0 |
| 33. Clay, grey micaceous | 3 | 0 |
| 34. Sandstone, white | 20 | 0 |
| TOTAL | 333 | 0 |

## NOTE ON THE GEOLOGY OF INDIA, *by* DR. W. WAAGEN, *formerly Palæontologist to the Geological Survey of India.*

(Translated from the "*Zeitschrift der Deutschen Geologischen Gesellschaft,*" Vol. XXVIII, p. 644, 1876.)*

The work which I do myself the honor of presenting to you is only in its later parts of very recent date. The first fasciculus has been already more than two years published. I have, however, noticed the general results only in a concluding chapter; and it is those especially which can be of general interest.

First, to rectify some errors which occurred owing to my illness and the consequent impossibility of my personal supervision of the preparation of the plates, I must mention that the last plate is altogether a failure, only the figure of *Crioceras australe* being recognisable. Instead of *Amm. Deshayesi* there is figured the fragment of a Planulata from the Macrocephalus-beds, under the title of "*Amm. Martini;*" and the true *Martini* is exhibited as "*Amm. Deshayesi,*" but delineated so that the figure is quite useless for the recognition of the species.† Other errors, such as the misnumbering of one plate, are easily detected and are therefore of less consequence.

The most striking result of the study of the Cutch ammonites is that the species identical with those of Europe are here also distributed strictly in the same horizons as have been distinguished there. This discovery is, indeed, due less to me than to the late Dr. Stoliczka, who, although fully convinced before his visit to Cutch that it is impossible to identify the European horizons in India, could not escape making the stratigraphical groups I have adopted in this work, and which do conform to the arrangement of the European zones.

It is also a very noteworthy fact, that among the ammonites the Macrocephala have a very different distribution in India from what they have in Europe; for they still occur numerously in a zone corresponding to that of the *Pelt. transversarium* in Europe. The species are, no doubt, clearly distinct from those of Europe; still they belong to the Macrocephala.

I have only noticed these two facts cursorily. I wish to speak more fully of the distribution of the jurassic strata in India, for upon this particularly depends to a certain extent the apprehension of Indian geology. It has been long known that the peculiar relation of Indian strata is that, while nearly the entire mesozoic formations are represented in the peninsula itself by thick sandstone deposits (Rajmahal, Mahadeva, Jubbulpur, &c.) with plant-impressions and some vertebrate remains, on passing to the North-West Himalaya one finds numerous marine fossils, which give certainty in the discrimination of the formations. On this account, according to Blanford's example, a Himalayan and a Peninsular type have been distinguished, and the areas compared with the alpine and extra-alpine formations of Europe. Only the Punjab does not seem to fit in this place, for there we find exclusively marine fossils, although one can scarcely place the neighbourhood of the Indus delta with the Himalaya. As a fact, however, this is the key to the solution of the whole problem.

* This communication was made by Dr. Waagen on the occasion of presenting his work in the Palæontologia Indica to the German Geological Society. Besides its direct bearing upon the geology of India, the paper is in many ways so illustrative, that it is worth while to reproduce it here.—H. B. M.

† A new plate is in hand, which will be sent to replace the defective one.—H. B. M.

In passing eastwards from the marine strata in Cutch and Rajputana, one comes at once upon the crystalline range of the Aravalis, to the south-east of which we only find the barren sandstones of the peninsular area. The Aravali range was never crossed by the sea (till the cretaceous period), and we have in the formations of the Peninsular type deposits from inland waters, which are manifold in their arrangement and therefore difficult to affiliate individually. They must, however, altogether belong to the Trias-jura period.

If we follow the crystalline rocks of the Aravali northwards, they become lost under the alluvial, nummulitic, or younger tertiary formations; but we behold to our astonishment that in the Himalaya, in the neighbourhood of Simla, the first crystalline ridge performs the same function as the Aravalis in the south,—namely, the separation of the fossiliferous marine clays and limestones from the thinly fossiliferous sandstone deposits. Poor Medlicott was wrongfully so much decried for his description of the neighbourhood of Simla. It is only natural that his Krol and Blini groups, if indeed they are not nummulitic, should not be found north of the first crystalline ridge; one must rather look for their equivalents in the south in Central India.*

The first crystalline range does not, however, remain the dividing line throughout the entire length of the Himalaya; for to the south-east in Sikkim the marine strata are already entirely cut out, and only one locality is known containing fossil plants. The sedimentary rocks are, moreover, here in great part converted into crystalline schists. The dividing line must cross to the north somewhere in Nepal and so extend into Tibet.

Thus is India traversed by an ancient coast-line which began with the Aravalis, probably reached the Himalaya west of Simla, then followed for a stretch the first crystalline axis and turned northwards in Nepal cutting obliquely across the whole Himalayan range. It seems, therefore, that the peninsula belonged to a great continent which probably included China, the Himalayan peninsula, the Archipelago and Australia, perhaps even a part of Oceania. The configuration was constant, with slight alterations, during the Trias-jura; great depressions set in with the chalk, which determined a great encroachment of these deposits, but already in mesozoic times India formed a peninsula as today, as is shown by the presence of triassic rocks in Burma, and marine jurassics north of Madras, which indicate a bay like that of Bengal.

The sea surrounding this peninsula was no doubt connected on the north with the European seas,—for how else could these seas have so many species in common? On the south it stretched away to east and west, as testified by the jurassic beds of South Africa and Australia, allied to those of India.

Especially remarkable is it that the Himalayan jura, although so near, is almost less like the Cutch jura than is the jura of West Australia; it is more like the Russian jura. Thus it would follow that the jura of Europe, Cutch and Australia, although in different provinces, forms in a manner a whole that one may at least designate as a homozoic girdle, while the jura of Spiti must indicate a similar girdle, to which that of Russia and Siberia must be affiliated.

* We were not aware of the criticisms referred to; but it would have been more to the point if Dr. Waagen had informed his hearers that several years later Dr. Stoliczka, the only competent observer who has visited both grounds, did identify conjecturally the Krol and Blini beds with the Triassic and Silurian beds of Tibet (see Memoirs Geol. Surv. Ind., Vol. V, p. 141). The conjecture still stands for what it may be worth. Dr. Waagen never set foot on Himalayan ground proper, *i. e.*, east of the Jhelum.—H. B. M.

Finally, I may mention that a part of the original specimens for the work before us seem to have been mislaid or lost during the transfer to the new museum building, as I am informed from Calcutta that several of the originals are not to be found.*

NOTE.—This key to the geology of India is one of the oldest on our bunch. But somehow the author of the paper must have taken a wrong impression of it, for his copy sticks in the lock. At least it seems curious how the recognition of the trans-Arvali rocks as belonging to the Himalayan region, should lead directly to the conclusion that the jurassics of Western India are more related to those of the antipodes than to those of the Himalayas. There must have been some difficult navigation round that ancient mesozoic coast-line, the course of which we here find traced with such accuracy, even into regions whose geology is absolutely unknown.

To any one who has attempted to understand the meaning of the correlation of widely separated deposits, even from copious fossil evidence, the assurance with which such conclusions as these are put forward will suggest want of confidence. If to the intrinsic uncertainties it be added that the data in this case are not abundant and have been only partially worked out, that collateral stratigraphical conditions are ignored, assumed, or misstated, the impression of doubt will become one of despair. The paper is one of a kind that is now only too common. The production of them is no doubt encouraged by the principle of mutual laudation which is the evil spirit of scientific societies. A curious collection, illustrative of this class of literature, might be made under the title, Oracular Palæontology. It must be a survival (largely Teutonic) of the barbaric instinct to deal in mysteries. The saying Arago applied to the geologists of his day may now be more fittingly addressed to their colleagues—" Je ne conçois pas comment deux pures paléontologues peuvent se regarder sans rire."

H. B. M.

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| | |
|---|---|
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Eastern Persia, 1870-72, Vol. I, Geography with narrative, by Sir F. J. Goldsmid, and Vol. II, Zoology and Geology, by W. T. Blanford (1876), 8vo., London.

INDIA OFFICE.

* Every one of the originals is now in its place in the new museum.—H. B. M.

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L'ADMINS. DES MINES.

Annales des Sciences Naturelles, Series I, Vols. I (1824)—XXX (1833); Series II, Vols I (1834)—XX (1843); Series III, Vols. I (1844)—XX (1853); Series IV, Vols. I (1854)—XX (1863); and Series V, Vols. I (1864)—XX (1874), with 9 Vols. of Plates and Atlas, 8vo., Paris.

Annals and Magazine of Natural History, 4th Series, Vols. XVIII, No. 108—XIX, Nos. 109-110 (1876-77), 8vo., London.

Archiv für Naturgeschichte, Vol. XXXI, heft 5 (1865), and XLII, heft 3 (1865 and 1876), 8vo., Berlin.

Geographical Magazine, Vols. III, Nos. 11 and 12; and IV, No. 2 (1876-77), royal 8vo., London.

Geological Magazine, New Series, Decade II, Vol. III, No. 12, and Vol. IV, Nos. 1 and 2 (1876-77), 8vo., London.

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London, Edinburgh and Dublin Philosophical Magazine and Journal of Science, 5th Series, Vols. II, No. 13—III, No. 16 (1876-77), 8vo., London.

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„ Geographische Mittheilungen, Supplement, Band XLIX (1876), 4to., Gotha.

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# RECORDS

OF THE

# GEOLOGICAL SURVEY OF INDIA.

**Part 3.]** **1877.** **[August.**

## NOTE ON THE TERTIARY ZONE AND UNDERLYING ROCKS IN THE NORTH-WEST PANJÁB,

BY A. B. WYNNE, F.G.S., *Geological Survey, India.*

THE object of these notes is to give some account of the westward continuation of the tertiary band which forms the subject of Mr. Medlicott's paper on the Jamú Hills (Records, Vol. IX, p. 49), and is also referred to in Mr. Lydekker's paper on the Pir Panjál (same volume, p. 155).

Both of these papers deal with the tertiary rocks about the valley of the river Jhelum and to the south-eastward of that region, while I propose to consider those forming the Ráwalpindi plateau and stretching westward to the Afghán Frontier.*

* Besides the two special papers mentioned, there are several others, amongst which those included in the following condensed list are of more or less importance, each containing some information about the district:—

| | | | |
|---|---|---|---|
| 1. | Vicary | ... Upper Panjáb and Peshawar | ... Q. Jl Geol. Soc. Lond., Vol. vii., p. 38. |
| 2. | Fleming | ... Salt Range | .. Jl. As. S. Beng., Vols. xvii—xxii. |
| 3. | Theobald | ... Ditto | ... Ditto do. do., Vol. xxiii, 1854. |
| 4. | Ditto | ... *Chelonian* from Potwar | ... Records, Geol. Sur. Ind., Vol x, pt. 1. |
| 5. | Falconer | ... Torty. fossils of E. Salt Range, &c. | ... Jl. As. S. Beng., Vol. xxiii, 1854. |
| 6. | Murchison | ... Salt Range | ... Q. Jl. Geol. Soc. Lond., Vol. ix, p. 89. |
| 7. | Verchere and de Verneul | Himalaya and Afghan Mountains | ... Jl. As. S. Beng., Vols. xxxv and xxxvi. |
| 8. | Lyman | ... Report on Panjáb Oil-lands | ... Public Works Dept.; Lahore, 1870. |
| 9. | Waagen | ... Carboniferous Ammonites, Salt Range | Mem. Geol. Sur. Ind., Vol. ix, pt. 2. |
| 10. | Ditto | .. Murree Hills | ... Records, Geol.Sur. Ind., Vol. v, pt. 1. |
| 11. | Warth | ... Salt Range | ... Reports, Inld. Revenue, 1869 *et seq.* |
| 12. | Waagen and Wynne | ... Sir Ban Mountain | ... Mem. Geol. Sur. Ind., Vol. ix, pt. 2. |
| 13. | Lydekker | ... Tertiary *Mammalia* | ... Records, ditto ditto, Vol. ix, pts. 3 and 4. |
| 14. | Ditto | ... *New Vertebrata (a)* | ... Ditto, ditto ditto, Vol. x, pt. 1. |
| 15. | Ditto | .. Ditto | ... Pal. Indica, Vols. 1 & 2, Ser. x-2. |
| 16. | Wynne | .. Upper Panjáb (*b*) | ... Q. Jl. Geol. Soc. Lond., Vol. xxx, p. 61. |
| 17. | Ditto | ... Trans-Indus Salt Region (*c*) | ... Mem. Geol. Sur. Ind., Vol. xi, pt. 2. |
| 18. | Ditto | . Mt. Tilla, Salt Range | ... Records, ditto ditto, Vol. iii, pt. 4. |
| 19. | Ditto | ... Pt. of Upper Panjab | .. Ditto, ditto ditto, Vol. vi, pt. 3. |
| 20. | Ditto | ... Murree | ... Ditto, ditto ditto, Vol. vii, pt. 2. |
| 21. | Ditto | ... Kharián Hills | ... Ditto, ditto ditto, Vol. viii, p. 48. |

(*a*.) In this paper a specimen of *Myliobatis* is said to have been sent by me from Kach: it is apparently from Katwár on the Salt Range, and was, I think, collected by Dr. Waagen.

(*b*.) Advantage may be taken of this opportunity to amend a few passages in this paper by knowledge since obtained: p. 62, the Siwaliks being miocene is now doubtful (Mr. Lydekker's papers, cit.). Table to face p. 63, last column:—the Tagling limestone is, according to Dr. Stoliczka, liassic; but in comparing the Sir Ban section with the Himalayan series it is placed as triassic, p. 64. The Púnch limestone has been since thought carboniferous, not Krol, p. 70. The conjecture as to there being hill-nummulitic beds near Uri in Kashmir was not supported by a subsequent observation, p. 74. In the section at Dandli, the beds *d3* have been found to overlie *e1* (Records, Vol. ix, p. 53).

(*c*.) Alterations necessary from subsequent information are mentioned in Mr. Medlicott's paper on Jamú.

I do not at present intend to pass beyond the subject of the tertiary zone further than to indicate briefly the rocks forming its supporting trough; and my notice of the newer formations will require less detail, because the rocks of the Salt Region beyond the Indus have been already described by me* as well as those of smaller areas in other parts of the district,† while a Memoir on the Geology of the Salt Range is in the press.

I must refer to Mr. Medlicott's paper, just now mentioned, for an account of the important changes affecting the tertiary zone on its passage from the country in which it was first examined by himself towards this district. Following out the geological features, he finds nearly every stratigraphical peculiarity of the Simla area vanish to the west. Though the upper and lower members of the great tertiary formation continue, the close identification of the intervening groups is still somewhat conjectural owing to the changes referred to.

The discovery that the whole zone was subject to such extensive modification as the total disappearance of marked unconformities, great boundary faults dying out by conversion into axes of contortion, or disappearing amid parallel stratification, was wanted to reconcile the earlier observations made in the Simla area with my own later ones in this district. The diversity of structure in the two regions will account for my having found it impossible to say which portions of the great conformable series in this part of the Panjáb represented each of the more clearly defined *discordant* groups of the Simla area; particularly as there is a prevalent general similarity throughout all the upper groups.

One of the local changes within the tertiary zone which may be analogous to the lateral variation affecting the whole formation as it passes westward, is the almost total absence of the very lowest beds of the sandstone series (as developed to the north) along the southern or Salt Range side of the trough. On the Himalayan side the uppermost nummulitic beds pass by alternation into the lowest part of the Murree group. On the Salt Range the junction is sharply defined, the parallelism of the stratification being the same in both cases.

Bordering this range there is a band in the sandstone series remarkable for the predominance of red clays, which, from its colour and nature, led me to suggest its being representative of the lower beds to the north. Below this zone, often close to the limestone, fossil exogenous timber is frequently found associated with reptilian remains. Similar petrified wood occurs in less quantity at a considerable distance upwards among the Murree beds on the northern side of the trough and Trans-Indus; but the red zone of the north, if present towards the Salt Range, is not sufficiently marked to be distinguishable. If this fossil wood can be relied upon to fix an horizon, it shows that a large part of the basal sandstone and clay series of the north side of the trough had died out in south and south-westerly directions.

In the Journal of the Geological Society of London,† I have discussed one of the most peculiar features of the country—the marked abnormal contact which forms the main northern boundary of the detrital tertiary rocks: it is not a single continuous fracture, but composed sometimes of several contiguous lines of displacement, amounting to more than ordinary faulting, inasmuch as it is generally attended by strong inversion of the outer rocks; and whether the ground it traverses be at an elevation of only one or of six thousand feet, nearly the same group of the upper nummulitic beds is always exposed along its southern side. On the other side of the line both nummulitic and Jurassic formations are in contact with these upper beds, which occasionally transgress its limits.

* See Nos. 17, &c., of list. † See No. 16 of list.

From its evident connexion with the Himalayan hills, I have attributed this abnormal contact to the out-thrust of the mountain mass on settlement, producing complicated inversion or oblique displacement. Although I do not think there is concealed unconformity present between the nummulitic groups on each side, I am not prepared to say there is absolutely none, nor can I venture to decide at what post-eocene period the dislocation took place.

The sub-division of the upper part of the great tertiary zone to the east has been carried out chiefly on the basis of slight lithological differences, or marked physical breaks, without collateral aid from the fauna so long known to exist abundantly in the newer beds. In this western district, these breaks being absent and fossil bones and teeth occurring also at lower stages than the usual horizon, the separation of groups has been still more tentative. It remains to be seen how far these divisions may be supported by palæontology, for the stratigraphical distribution of the fossils has not yet been fixed.

Amongst the lowest tertiary beds, the greater limestone groups of this district are conspicuous. The intervening band between these and the sandstones, &c., has been identified as Sabáthu (in part), but the upper members of the triple Sirmur group, peculiar to the middle Himalayan area, have their nearest equivalent in the "Murree beds," transitionally overlying the upper nummulitic rocks here. The higher portion of these Murree beds would also seem to occupy the place of the Nahan group, and they pass upwards into the Siwalik sub-divisions, continuous with those of the adjoining Jamú country.

The local characters of each of the four large nummulitic areas of this country present themselves strongly: the great limestone covering the Salt Range differs entirely from the even more largely developed nummulitic limestone of the outer Himalayan hills, and the upper transitional nummulitic group on that side of the basin shows both affinities and differences compared with the limestones beyond the Indus. These last are distinguished from all the rest by their close association with the great rock-salt deposits of that country and its overlying gypsum, a rock, however, frequently occurring in smaller masses among the upper nummulitic beds conterminous with the outer Himalayas.

The question has been raised whether the whole of the great nummulitic limestones of this country are not merely equivalents of parts of the Sabáthu zone of the Simla and Jamú areas.* I have concluded that these massive limestone groups occupy a lower place or places in the series than the variously-coloured and mixed calcareous and earthy (Sabáthu) deposits, for the following reasons:—These beds of limestone, clay, and sandstone (here recognised as Sabáthu) enter and leave the district as a more or less distinct band, external to the hill nummulitics, and passing into the overlying sandstone and clay series. These mixed beds, as an assemblage, differ from the mass of the limestones on the inner side of their boundary-fault or line of abnormal contact. That feature and the disturbed condition of the ground prevent the sequence from being seen, but towards the same side of the trough, in the Khaire Múrut ridge, I have found a section at a place called Chorgali clearly showing the whole of the local upper group resting conformably upon the more massive and clearer limestone of the older part of the series (see p. 118). Both groups being present in the same section, one cannot be the representative of the other.†

* Messrs. Medlicott and Lydekker's papers alluded to at commencement.

† Accepting Mr. Wynne's use of the term "Sabathu," any argument in the matter would be needless, for it is perfectly evident that the coloured and mixed deposits west of Murree to which he restricts the word "Sabáthu" do overlie, and cannot represent, his hill limestone. But this name is one of our oldest Indian group-names: for many years the name "Sabáthu" has stood to mean the nummulitic rocks of the outer Himalaya; and in its typical region, and very well marked through the Jamú hills, there is a bottom band of clear limestone under the coloured clays, and having, if possible, a higher claim to the name than they have. It has been reasonably suggested

The fault or contact-line, by its existence, proves the same thing: if there be displacement, the groups on each side cannot be exactly identical: if no displacement, there is no room for lateral transition; and if there should be unconformity, the groups must be even more distinct. The great limestones overlie, with conformity, actual in the Salt Range and apparent in the northern hills, cretaceous and Jurassic rocks, a relation in which the upper nummulitic beds are never found; on the contrary, these are united by intercalation with post-nummulitic rocks.

Notwithstanding, there are places in the other areas in which a certain resemblance to the upper nummulitic character is found. The Salt Region beyond the Indus is one of these, and at the eastern end of the Salt Range (near some typical "Murree beds") there are a few layers at the top of and above the nummulitic limestone which have an "upper" aspect.

Some of the local distinctions between the four nummulitic areas above mentioned coincide with marked variety in the *facies*, the size, or the abundance of their fossils. I am unable to state how far specific differences may exist, the collections not having undergone palæontological examination; but the impression of both vertical and horizontal distribution was gathered in the field. If this be the case, the conditions of one province may have invaded another, and thus blended the characters of deposits, generally contemporaneous no doubt, though perhaps not strictly synchronous one with another.

All the tertiary rocks under notice are, so far as is known, conformable and consecutive. The most distinct demarcations between the different groups occur:—at the top of the Salt Range nummulitic limestone where in contact with the Murree beds; and, between the upper and lower nummulitics, by reason of dislocation, at the northern side of the trough. Beyond the Indus the upper boundary of the limestone is frequently as distinct as in the Salt Range, but there are also obscure indications of transition by alternation upwards. All the other junctions are more transitional and indefinite. To such an extent is this the case, that it is impossible to say exactly where the change took place between the older marine and the newer fresh-water conditions.

Although stratigraphical conformity is obvious throughout the tertiary series, there are traces at several horizons of local breaks not otherwise apparent than by the presence of derived pebbles belonging to older portions of the same series, in some instances accompanied by small fragments of still earlier rocks. It is only at the upper limits of the Salt Range and Trans-Indus limestone that these derived nummulitic and other pebbles are coincident with the boundaries of any of the sub-divisions; they are elsewhere not limited to particular horizons.

A sketch map of the country herein referred to is annexed. It is on the same scale as that to accompany Mr. Medlicott's paper, and has the same colouring for the tertiary groups, the distinction now suggested of upper and lower nummulitics being also indicated. Both maps, joined at the meridian 74°, will convey a comprehensive view of the tertiary region of the Upper Panjáb.

## PHYSICAL FORM OF THE GROUND.

The space referred to in this paper may be spoken of as lying between the Salt Range to the south and the outer Himalayan hills to the north, and extending from the river Jhelum

that this rock specifically represents the "Hill limestone;" and that its greater development to the west may have so taken place, that, partly at the expense of the upper deposits, the two would be in part representative of each other in the different regions. But this latter part of the conjecture is quite independent of the former, which scarcely admits of question: if the distinction of an upper and a lower nummulitic zone holds good, as is not unlikely, it will have to be carried out in the Jamu hills as well as in Hazára.—H. B. M.

westward across the Indus to the Kohát frontier. It includes the whole of the Ráwalpindi plateau, or "the Potwár," a name strictly belonging to an eastern portion of the plateau, but sometimes used even by natives of the country in a more comprehensive sense.

This ground, having an area of about 7,000 square miles, forms an undulating expanse edged by the northern slopes of the Salt Range, and lies about 1,000 feet higher than the alluvial plains and desert south of that range. It appears analogous to the Dúns of the Southern Himalaya, and is in reality one of the most strangely broken tracts I have seen, intersected by numberless deep, ramifying ravines called "*khadera*," the rapid extension of which is attested by the isolated remnants of the neighbouring "*maidán*" (or plain) included amongst them. The heads of all the streams not in the hills issue from such a fretwork; and along the larger water-courses, though wide flats of auriferous sand and quicksand form their lower levels, ordinary alluvial border tracts are rare.

From this plain or plateau rise a few reefs of bare rock, often only narrow, jagged, vertical walls, and one more considerable mural ridge called "Khaire Múrut" (over twenty-two miles long and reaching to 1,500 feet above the adjacent country) runs west-by-south from the neighbourhood of Ráwalpindi.

The Murree hills, twelve to twenty-eight miles distant from the same station in an opposite direction, culminate in heights of over six, seven, and eight thousand feet, declining in successive nearly parallel ridges towards the direction of Jhelum cantonment. They have a general south-west north-east trend, which is also that of most of their numerous, sometimes sinuous, axes of contorted stratification, the folds being most compressed northwards. All the ridges are united by a zigzag subordinate backbone, forming the Cols, and rudely conforming to the adjacent course of the Jhelum.

Ridges at their eastern ends parallel with these, then bending more to the west, form high mountains immediately north of the Murree hills. Towards the plateau they decline; and the Grand Trunk Road passes through gaps near their western termination at the Márgala Pass. Beyond these again rise the Hazára hills, and the fine range of Gandgarh partly bordering the Upper Indus.

From the Márgala pass two ranges run westward south of Attock; gaining in elevation they unite to form the lofty Affrídi hills overhanging Kohát; then passing south of the Peshawar valley they culminate in the Khybur mountains and Sufécd Koh of Afghánistán. The most southerly of these, called the Chita Pahár, edges the Ráwalpindi plateau on the north.

In the Kohát district the part of the ground under notice presents a series of long ridges, closely clustered, running more or less east and west, often crooked and of varying but not insignificant height. Viewed from the plateau, they assume the appearance of a connected range. The valleys between these are for the most part rugged; but some flat cultivable patches enhance the sterility of their generally treeless surroundings. A few high summits occur near the Indus, and the whole cluster lies between the Afghán hills and the Shíngarh chains to the south.

The Salt Range which edges the Ráwalpindi plateau southwards and is sinuously prolonged Trans-Indus, in both places presents wild and mostly unfertile tracts. Cis-Indus it forms a precipitous escarpment overlooking the "Thal" (or desert) and lower plains. Further west, with numerous disturbances and dislocations, the northern inclinations of its strata rise to steeper angles, and the stronger beds support a mass of tertiary rocks, whose deeply serrated outline, Trans-Indus, and the silvery sheen of its bare sandstone summits, betray the presence of the upper tertiary series, making the Pushtu name *Shíngarh* as suggestive in its half English sound as in its vernacular meaning of "Grey mountains." The northward extension of these rocks, however, in the direction of the dip is interrupted by faulting; most of the lower ground and hills towards Kohát being occupied by older parts of the series.

*Drainage.*—Crossing this whole tract of tertiary rocks, the Jhelum river is a racing, rapid torrent, hemmed in by mountains; the Indus (or Abba Sín), larger and more powerful, flows from among lofty and picturesque ranges, across an expanding and highly cultivated plain, till it receives the Lúnda or Kábul river at Attock. It then cuts its way through every one of three intervening ranges, and has formed for itself a deep narrow gulch through the rocks of the plateau, running swiftly, with occasional rapids, until it reaches and escapes into the lower plains at Kálabágh. The minor drainage of the district mainly seeks the Indus, some smaller portion reaching the Jhelum. It is everywhere distinguished by its cross-country character, preferring, in many cases, to intersect the hilly or mountainous ranges rather than to follow the larger depressions of the surface. Even the Soán, the most considerable local stream, rises in the hills at Murree, not very far from the Jhelum, yet wanders away westwards to the Indus, by a part of the plateau-land which itself sends affluents to the Jhelum river through ridges of the Salt Range. The Haró, too, in the Hazára valley to the north, does not take all that drainage to the Indus, for the Dore, which would otherwise form one of its upper tributaries, turns aside, crosses through part of the lofty Gandgarh range, and finds thus a shorter way to join the great river at Turbela. The Tíri (Teeree) Towey, another tributary of the Indus, from the Kohát district, changes its course from one depression to another, intersecting the ridge between.

These peculiarities of the drainage tend to show that its course was initiated more directly by agencies of elevation than by the results of atmospheric denudation acting, at different rates, upon rocks of varying texture. The valleys of the ground are not always those of the rivers; both are now valleys of denudation, but the directions of the streams were decided by much older contours of the surface than now exist. The rivers have maintained their courses, even though the wasting agencies in carving out prominent features have at the same time lowered the "divides," in some localities to hardly noticeable undulations.

The antiquity of the courses of the larger rivers Jhelum, Indus, and Kurram is proved by the Himalayan transported detritus, brought to form late tertiary (Siwalik) boulder beds and conglomerates, being thickest near their banks.* A later phase in their history is marked by the occurrence of the same hard detrital and stream-worn blocks lying upon the adjacent mountains at heights of about 2,000 feet above the present bed of the Indus; † and a still later period of the river action is indicated by the same pebbles and boulders interstratified with the superficial deposits of the country along this river Such hard boulders now form its bed at Attock, and are doubtless still travelling downwards from the Himalayan regions.

## CLASSIFICATION.

The rocks found in the district may be classified as follows :—

| | *Natural order.* |
|---|---|
| POST-TERTIARY—<br>*Unconformity.* | Conglomerates, pebble beds, silt and alluvium. |
| UPPER SIWALIK—Pliocene (Lydekker), ‡ about 4,000 feet. | Brown, drab, and reddish clays, mammalian and reptilian remains.<br>Soft grey sandstones, conglomerates, and orange or grey clays. Mammalian remains, &c., not abundant. |

* This feature was pointed out for the Mid-Himalayan rivers long since by Mr. Medlicott.

† Over Kalabágh, and again on the Chita Pahár (Mountain) near their highest elevations above Bág and Choi.

‡ Records, Geol. Surv. Ind., Vol. IX, p. 87.

| | |
|---|---|
| LOWER (RED AND GREY)[1] SIWALIK—Pliocene (Lydekker), about 10,000 feet. | Soft grey sandstones and brown or grey clays, slightly harder grey sandstones, many red clays; mammalian remains, bones, teeth, &c., locally abundant. Ossiferous throughout. |
| MURREE BEDS—Upper Miocene (Lydekker), 7,500 feet average. | Harder grey sandstones, with soft zones, red or purple clay. Fossils—reptilian and other bones not numerous, some fossil wood. At Salt Range, purple and grey harder sandstones, red and purple clays, a few green sandstones (locally); reptilian remains, exogenous wood, bones scarce, and fragmentary teeth rare. |
| NUMMULITIC—Eocene to Miocene (Lydekker). Upper 800 feet average. | Greenish-grey and purple sandstones, grey, olive-brownish, red and variegated clays with masses of rock gypsum. *Foraminifera*, (*nummulites*, &c.), *Gastropoda*, Bivalves, fossil mammalian bones occasionally. Crustaceans rare. |
| Lower ... Trans.-Indus 1,700, Salt Range 500, Himalayan 3,000 } Average 1,066 | In Salt Range, Trans-Indus, and part of Chita Pahár. Whitish or usually pale limestones, coaly shales, &c., below. In Kohát district are sandy limestones, olive shales, and red clays also, as well as gypsum and rock salt. Fossils, *Foraminifera* (*Alveolina* locally numerous), large *Gastropoda*, Bivalves, Echinoderms, &c. Northern or hill nummulitic, grey limestone weathering pale, dark fœtid limestones, olive shales: *Foraminifera*. |

*Obs.*—Series parallel and conformable from the pale limestones upward to top of Siwaliks. The boundaries of the groups are transitional and indefinite.

The downward continuation of the series, so far as now known, includes the following formations:—

*Southern or Salt Range series.*

| | |
|---|---|
| Cretaceous (?) | Sandstones, conglomeratic clays, shales. |
| Jurassic | Sandstones, limestones, oolite, &c. |
| Triassic | Limestones, shales, red sandstone and clays. |
| Carboniferous | Limestone, sandstone, shale. |
| Speckled sandstone | Sandstones, clays, conglomerate. |
| Magnesian sandstone | Dolomite, pseudo-limestone, shale, sandstone. |
| Obolus beds (Silurian) | Dark, clunchy, shaly and sandy beds. |
| Lower or purple sandstones | Purple sandstone, replaced by conglomerate. |
| Gypseous series | Scarlet marl, gypsum, rock-salt. |

*N. B.*—The series differs at either end of the range by absence of, or changes in, certain groups.

*Northern or Himalayan series.*

| | |
|---|---|
| Cretaceous | Limestones, some rusty and sandy. |
| Jurassic | Limestones, sandstones, black (Spiti) shales. |
| Triassic | Limestones, magnesian in part, shales, sandstones. |
| Infra-triassic | Silicious and dolomitic breccia, shales, sandstones. |
| Silurian (?) Attock slates (azoic) | Black and grey slates chiefly, limestones, magnesian in part, trap. |
| Metamorphic | Part of the Attock slates usually slightly altered. |
| Crystalline | Syenite-gneiss, trap rocks, and granitoid rocks. |

*N. B.*—Carboniferous rocks are unknown in the northern series of this district, but occur in Kashmir and to the east of the Jhelum (see Mr. Lydekker's paper on Pir Panjál).

In describing the rocks belonging to the different tertiary groups, I shall follow what is known or appears to be their chronological order, commencing with the earliest.

## NUMMULITIC LIMESTONES.

*Hill Nummulitic beds.*—Of the four local kinds of nummulitic limestone the oldest perhaps is that of the outer Himalayan hill region: its position and general aspect, with its less fossiliferous character and the manner of its association with the mixed groups, are points giving sufficient grounds for a strong inference that this is the case. It is, generally speaking, dark-coloured, fœtid and massive, with nodular or lumpy bands, the whole irregularly and locally interstratified with masses of brownish, olive or darker shales.

Strong zones of paler grey splintery limestone also occur, and towards what appears to be the upper part of the group, the limestone, though still darkish, weathers of a lighter bluish-grey colour. Stratification is sometimes most plainly seen, sometimes nearly impossible to detect, and disturbance, compression and dislocation have left the succession obscure.

Those beds overlying the next older rocks are either unfossiliferous or only contain black specks that may have been organic, with occasionally minute sections of discoid foraminiferous organisms, having a single tier of cells arranged as a helix; or else cross-sections of another minute form less than semi-circular, with an obtuse angle midway opposite to the curved side, subtended by three or four concentric chambers equally divided by a closely set group of radial septa. I have only found this form in the lowest beds, and have not been able to get it determined. In the shales much higher up in the group are sometimes clumps of very small clustered and branched corals with occasionally numerous little *Foraminiferæ* (similar to the discoid form just mentioned) referred conjecturally by Dr. Waagen to *Rotalinæ*.

Many of the limestones enclose nummulites, whose sections are generally small in size, varying from that of the longest to the shortest diameters of grains of rice or wheat. The whole assemblage of organisms in these hill-beds is distinguished by scarcity and minuteness as compared with the other nummulitic rocks.

Westward, the darkest-coloured limestones are less common, the shales thinner and not so frequent. Strong grey limestone, weathering lighter, occurs along the Chíta range ; still the dark shaly variety, with lumpy bands and a few layers crowded with small oysters, appears in the more central, northerly, and western parts of the range, also in the Niláb Gash mountains beyond the Indus. Yellow ferruginous, magnesian-looking bands are occasionally present, and there are black alum-shales in one or two places at the base of the series which may be of an older formation. At one place (Choi), apparently much higher in the group, is a lenticular pocket of bright coal and coaly shales, amongst the ordinary dark limestones and brown shales. Thin carbonaceous shale also occurs locally between these limestones and the Jurassic beds at Chamba Peak north of Murree, but are not constant in that position.

North of Niláb-Gash, at Pullosi Pass, grey limestone contains casts of large *Lucinidæ* similar to those of the Salt Range; and near Shaladetta I found, loose, one of the great Gastropod casts (*Cerithium ?*) peculiar to the Salt Range limestone. These indications are, however, too slight to establish any close identification of the northern limestone group with that to the south. They are lithologically different accumulations, although they appear to be generally contemporaneous as upper and lower parts of the same formation.

The Khaire Múrut ridge is a mass of solid, contorted, grey nummulitic limestone (of the same kind as that found in the eastern part of the Chíta Pahár opposite), flanked by the upper nummulitic group faulted, overthrown and concealed by talus deposits, yet well exposed where it forms the western and lower extension of the ridge. The stronger limestone, and indeed the whole ridge, appears to have had an anticlinal structure greatly modified by compression and faulting. At the eastern end in the lower ground are some indications of the conformable succession of the newer nummulitic group to the hill limestone, and again westward at Chorgali* I found the succession and conformity of the two groups distinctly displayed. (The section will be noticed when writing of this newer zone.)

Under the conditions of disturbance and dislocation it is hard to conjecture what may be the correct thickness of these hill limestones and shales. An attempted estimate carefully

* A pass infested by robbers in the Sikh times.

taken from one of the most detailed sections I have got near Murree* shows thicknesses for parts of the formation of over 2,150 and 2,700 feet; this is, however, but a partial result, and the whole may much exceed 3,000 feet. There is a large group of light-coloured evenly bedded limestones in the Hazára hills which appears intermediate between the hill nummulites and the cretaceous rocks.

*Salt Range Nummulitic Limestone.*—In this region the formation is made up almost entirely of limestones presenting a greater unity of character and uniformly a much paler colour than the northern group. Intervening clay or shales are rare or absent, and where any occur, they partake of the light colour of the limestone. Nodular or lumpy beds, made up of solid portions surrounded by a softer coating, are not uncommon; compact and cherty limestones often predominate in the upper portion. Many of the beds are highly fossiliferous, containing numerous imperfect casts of large Gastropods more than 8 inches in height, or large Bivalves, and also Echinoderms frequently as large as small melons. One small fossil, *Ostrea Flemingi*, seems exceptionally well preserved. *Nummulites* are numerous, and *Alveolinæ* also occur, as well as other *Foraminiferæ*.

In the Eastern Salt Range layers of pale purple and yellowish limestone conglomerate, with limestone and flint nodules and pebbles, the matrix charged with small *Nummulites*, have been found to form the very uppermost few beds, conformably overlaid by the sandstone and clay series. In the somewhat outlying Diljaba and Bakrála ridge these beds re-appear at Goragali, but separated from the limestone by a mass of greenish shales several feet in thickness, and having much the appearance of the upper nummulitic beds on the north side of the tertiary belt. Some red flakey clay or shale is also associated.

At the base of the Salt Range nummulitic formation dark shales are very commonly present, frequently overlying white, sub-conglomeratic, coarse and fine sandstones interstratified with pale red sandstone bands and red or lighter grey (rarely gypseous) shales.† The dark shales are often coaly or contain a single or divided layer of bright coal averaging three feet (the Salt Range coal). Mottled red and white unctuous or lateritic clay occurs as an accessory in thin or thicker beds. These lateritic and hæmatitic layers sometimes occur at the very base of the limestone, and sometimes below the coaly shale or among the white sandstones. They vary a good deal as to the amount of iron present, are sometimes pisolitic (when the grains are used as shot or bullets) or replaced by white clay, and they are sometimes altogether absent.

The coaly shales are not the very lowest nummulitic layers. At places in the East Salt Range, where most carbonaceous, one or two underlying calcareous beds contain nummulitic fossils; and to the west, as in the Bakk ravine (Músakhel), a considerable thickness of nummulitic limestone separates them from the lower formations. This variegated and mixed band below the main limestone has in the eastern region a probable thickness in some places of more than 200 feet, but parts are often concealed by talus deposits. It is less prominent to the west.

The whole southern nummulitic group frequently shows itself in high cliffs and varies in thickness from about 500 feet to nothing, being entirely absent in places at either extremity of the range Cis-Indus.

* The observations for this section were mapped on a scale of 300 feet to an inch and carried along the clea cuttings for the new road between Murree and Abbotabad for over 23 miles. I look upon its information, as fa as it goes, as reliable.

† At one place south of Chel hill, East Salt Range, a layer in such shales not far below the limestone contain narrow, pointed leaves.

Upon the evidence of the arenaceous, argillaceous, and rarely gypseous layers below this Salt Range limestone,* or the small local development of layers with an upper character at top, I can scarcely venture to assert that the whole group is the counterpart of the upper nummulitic beds of this district or elsewhere; still I think there may be sufficient reason to suppose that similar conditions recurred at intervals, and that this Salt Range series may at least be, generally speaking, newer than the greater part of the northern hill nummulitic limestones †

*Nummulitic Limestones, &c., beyond the Indus.*—I have so lately described these rocks, (in Vol. XI of our Memoirs,) where as yet I am best acquainted with them, that a short notice will suffice. The most striking and constant band is one of hard grey and often variously tinted pale compact limestone 60 to 100 feet in thickness. This in colour and texture has some resemblance to bands in the Salt Range: it contains *Nummulites* and *Alveolinæ*. Below it are other grey lumpy and sometimes cherty limestones, with various nummulitic fossils; some peculiar to this region, and none possessing the great size of some Salt Range forms.

Underneath these limestones there is a zone of deep red clay, having subordinate sandstone and hæmatitic layers; it varies from 1,500 to 400 feet in thickness, and in places contains small fragments of fossil bones. Locally this clay gives place to olive sandstones partly conglomeratic; greenish clays and impure limestones with *Alveolinæ* and *Nummulites*. This mixed group reaches a thickness of 100 to 350 feet. Below all are the alum shales, the massive layers of gypsum, gypseous clays, and the enormous accummulation of rock-salt, often distinctly and regularly stratified. In the upper part of the series there are appearances of alternation with some of the overlying purplish sandstones, &c., but the folding and inversion of the rocks is so intense over the district that appearances cannot be always trusted.

The united thickness of the Trans-Indus nummulitic rocks, including 700 or 800 feet for the rock-salt and 300 for the gypsum, is estimated at from 1,600 to 1,700 feet, and may

There are points of resemblance between this series and that of the Salt Range, but also many differences. Where the limestones are thick, pale, and fossiliferous, the resemblance is strongest; and junctions between the limestone and overlying sandstones, though often *locally* resembling the sharpness and definition of the same in the Salt Range, have here and there more similarity to the transitional nature of the newest beds of the whole nummulitic formation. The Trans-Indus nummulitic area has therefore general characters intermediate between those of the Salt Range and upper nummulitic groups, and is most nearly allied to the last.

*The Upper Nummulitic group* of this country, coming from the eastward, appears first in the Murree hills, then passes westward, edging the outer Himalayan region, crosses the Indus at Báhtar, continues close along the south side of the Niláb Gash mountain, and leaves the district as a continuous zone to enter the Jawaki Affrídi hills. A spur from these hills to Dandi on the Indus has beds upon its flanks which may belong to the group: it re-appears, at Khaire Múrut ridge, deeply faulted into the *khuds* and mountains of the Hazára district north of Murree, and similarly placed in the Mírkulán pass south of the Peshawar valley.

* The coaly shales afford no point of comparison, no similar zone occurring in the upper nummulitics of this district, nor any band that could be safely referred to the same horizon among the northern hill limestones.

† The East Salt Range nummulitic group presents a most striking resemblance to the bottom beds of the nummulitic series throughout the Jamú hills.—H. B. M.

The rocks consist of greenish drab, grey, red, and deep purple clays or shales, associated with masses of gypsum and alternating with thin layers of buff, grey, or bluish limestone frequently of lithographic texture, sometimes whitish and marly. Among the calcareous beds many are little else than aggregations of *Nummulites*, *Operculinæ*, &c., but sometimes their matrix is a dark green or yellowish or reddish sandstone, and sometimes greenish clay or shale. Beds entirely composed of small Bivalve casts or of *Turritellæ* occur, but more rarely, and with the former, fragments of small Crustaceans have been once observed. The marine fossils are greatly more numerous individually in these upper beds than in any other nummulitic rocks of the country. Large mammalian bones or smaller fragments have been also found in this group, occasionally with *Nummulites* attached.

The group varies as to predominance of any of its ingredients; sometimes limestones and sometimes clays are most developed below; and in places there are but few calcareous layers present. Strong zones of yellowish grey sandstone appear in westerly localities, while eastwards a great thickness of bluish grey sandstones and purple clays resembling those of the overlying series are included. These are without fossils, except fucoidal impressions.

One remarkable but thin contact layer occurs here and there where the main group of limestone beds is overlaid by sandstones. It consists of a nodular and conglomeratic limestone, passing into calcareous sandstone, and containing concentric concretions with subangular lumps or pebbles of fossiliferous nummulitic limestone. Strings, layers, and groups of *Nummulites* occur also in the paste. Subject to variation as to its conglomeratic aspect, it has been found at different places in this northern band, also along the Salt Range and Trans-Indus, with one exception always marking the junction between limestone and sandstone stages. This exception is where a limestone band made up of small concretions weathering detached (otherwise a junction or representative layer)* was found interstratified with Murree beds, north of the Dúga stream, between Mári and Jand. The layer has some importance, tending to unite the groups last described with this, if it can be taken to mark an horizon, but appears to occur accidentally (like other nummulitic layers among the lower Murree beds) in the exceptional case noticed.

The character of transition and unity with the overlying Murree beds is marked along the place of junction by alternations of rocks which might belong to either group. Sandstones and clays like those overlying are common, and limestone layers occur considerably removed from any other upper nummulitic rocks. Beyond the Indus such appearances are more frequent. Towards the Murree hills, limestone bands, very similar to that of the adjoining mountains, are associated with these upper nummulitic rocks: the disturbance is, however, so great, that it is not clear whether they are sometimes intercalated or introduced by faulting. In some cases, though dislocated, they appear to belong to this group, in others to be separated by faulted portions of it from the remainder of the hill beds.

Disturbance also obscures any very satisfactory estimate of the thickness of the group. From contorted sections in the lower ground this was found to measure more than 1,500 feet. Mr. Lyman gives 500 feet for the more calcareous part of Fatahjang, and after deducting probable repetitions in the Kúldana section (where the great bulk is made up of beds similar to the Murree sandstones, &c.), there would remain, according to that exposure, 6,525 feet. The rocks occupy a space more than a mile in width across the strike, including, among the furthest from the hill nummulitic beds, a strong zone of limestone of 750 feet, apparently displaced. It is difficult to believe in this great thickness, but I have tried to restore the section, so as to unite the strong outer limestone with that of the hills, by means of supposed

* See Trans-Indus Memoir, pp 105, 118, 151.

faults, without success or probability; unless the 750 feet of limestone and some adjacent undoubtedly upper beds may have once formed part of an anticlinal curve, all trace of which is now lost.* Independently of this doubtful section, the group may be taken as including from 500 to 1,500 feet of rocks.

The place of the whole upper beds as newer than the more solid and massive limestones occupying a central position in the district, is fixed by the following section found at Chorgali (Khaire Múrut ridge) southwards from Fatahjang: thickness about 400 feet; inclination generally high to the north and turning over southwards:—

| | |
|---|---|
| LOWER, TRANSITIONAL PART OF MURREE BEDS ... | Purple, grey, and greenish sandstones and pseudo-conglomeratic concretionary beds; clays, if present, concealed; rocks locally crushed in places. |
| UPPER NUMMULITIC ... | Hard whitish sandstone, including a mass of nodular limestone.<br>Pseudo-conglomeratic, calcareous, concretionary "junction-layer" with concentric concretions and subangular lumps; nummulitic limestone; strings, layers, and groups of *Nummulites* in the paste.<br>Lumpy limestone with purple and dark shaly partings.<br>White splintery shales.<br>Strong lumpy limestone.<br>Mass of pale greenish shale, with two beds of earthy limestone; whitish hard, marly limestone, alternating with a few lumpy layers below; conforming to an arch of,— |
| LOWER NUMMULITIC .. | Hard lavender-grey nummulitic limestone of the same kind as forms the nearest part of the Chíta Pahár range and the mass of the Múrut ridge. |

The massive gypsum, red clays, and most highly fossiliferous beds are wanting here. This, together with the scanty representatives of the group in the few uppermost layers of the Salt Range much further southwards, may indicate a gradual disappearance of the zone in that direction, or even by lateral transition, it being represented in the upper portion of the Salt Range limestones.

It is in this upper group that the principal petroleum springs of the country (such as they are) are situated. The mineral oil does not appear to be confined to any particular horizon or even to the group, being found among limestones nearly in the middle of the Chíta range, in the nummulitic beds beyond the Indus and impregnating the salt in places. It occurs just below the junction of the limestone with the overlying sandstones at Jaba in the Western Salt Range, and there are traces of it in the sandstones of the Murree group near the Múrut ridge. Sulphur springs often occur in association with the oil.

*Murree Group.*—In this great transition group the passage has probably taken place from the nummulitic marine conditions to those of the fresh-water series above. Among its very lowest layers, which are inseparable from the underlying group, I found a bed close upon the limestone, containing thick, strongly ribbed shell-casts of marine aspect (a *Cardium ?*), associated with numerous and large crocodilian remains (see Trans-Indus Memoir, pp. 130, 135). In detail these rocks include harder sandstones than occur higher in the series, often of pale grey or purplish colour below, and crowded with obscure plant-impressions resembling Fucoids associated with Annelidan markings. Such beds are not unfrequently ripple-marked.

A strong purple colour pervades the whole lower portion of the group, which shows an endless alternation of red and purple clays, with purple and greyer thick or thin sandstones and concretionary earthy or slightly calcareous bands. In upper portions and among southern representatives of these Murree beds, pale, soft, grey or greenish sandstone zones are intercalated with the more usual purplish clays and sandstones. To the southward, also, and more

* For further details of this section, see Records, Vol. VII, Pt. 2.

rarely elsewhere, conglomerate or pebbly beds are found containing rounded fragments of nummulitic limestone, sometimes with hard pebbles from still older rocks. These are pretty often seen in the ground about the eastern extremity of the Salt Range.

Other fossils are not numerous in the Murree beds, yet scattered bone fragments, crocodilian teeth, or scutes and pieces of exogenous fossil timber may be found near its southern base. These remains are locally numerous on Mount Tilla, along the Salt Range and beyond the Indus. Bones occur immediately over and partly in the upper surface of the nummulitic limestone at a pass on the road to Kohát from Kushálgarh near Gúrgúrlot mountain; again in the lowest sandstones at the northern end of the Chicháli pass in the Shín Garh mountains; occasionally in the neighbourhood of Fatahjang, and rarely at the foot of the Murree hills. In many cases they are too fragmentary for identification; some large specimens, however, of mammalian bones appear among these rocks on the Bakrála ridge near Doméli. In the same range, over Bakrála pass, and also near Zyarut, west from Jand towards the Indus, I found fragments of the teeth of *Mastodon;* but the best fossils of the group are those recorded by Mr. Lydekker (Records, Vol. IX, pt. 3, & Pal. Ind. cit.) from Kushálgarh, found at some now unknown locality, and including *Mastodon, Dinotherium, Listriodon, Rhinoceros, Antoletherium, Sus,* and *Amphicyon.**

Intense disturbance, and along its northern limits inversion, greatly obscure the thickness of this group, which must be nevertheless very large. The whole of the nearer hills south of Murree and the Murree ridge itself are formed of its beds; one steeply inverted portion at that station some 2,600 feet in thickness forming but a small portion of the ridge. In the lower ground there are appearances of nearly vertical beds for miles across the strike, but these are most probably produced by compressed folds, the upper parts of which have been denuded, for in the general strike towards the Indus the rocks are seen to be closely contorted. The beds occupy a width of from ten to sixteen miles across the northern side of this district; beyond the Indus they appear thinner, yet still form a prominent purplish belt round each of the disturbed nummulitic anticlinals of that country, and along the Salt Range they have certainly lost thickness as well as much of their characteristic aspect. On the whole, 5,000 to 8,000 feet may not be too large an estimate for the group.

The newer tertiary rocks being all transitional, it is as difficult to fix a definite upper boundary for these Murree beds as to separate them from the rocks below, yet the brighter colours of the clays and sandstones upwards are sufficient to indicate some difference and an approach to the newer groups. The marine nummulitic conditions were no longer present, and there is no certain trace of the land surface on which the timber grew which is found fossilised in these Murree rocks, for all the specimens appear to have drifted from other places to where they are now found: the presence of mammalian bones and crocodilian remains are, however, indication that land was not far distant.

*Lower Siwalik.*—The rocks succeeding the Murree group in conformable sequence, where not faulted against it, are clearer and brighter grey sandstones and red clays, the uppermost parts of the clay bands having frequently grey or rusty tints. For want of a distinctive name which should not imply an identity not proved, I called these the "red and grey group," but they have since been traced into continuity with the lower and most fossiliferous portion of the Siwalik beds of the Jamu country: there is, therefore, no longer any doubt of their position in the series.

The passage is so gradual from the lower (Murree) group that the predominance of red over purple in the clays or a cleaner grey colour of the now softer sandstones afford but

* These have been noticed by Falconer and others as Attock fossils. The association of the name of that distant locality, where older azoic rocks only are found, is very inappropriate.

faint indications of a somewhat indefinite individuality. Finely concretionary pseudo-conglomeratic layers very similar to others in the group below are common, and conglomerate bands with derived pebbles from the underlying limestone and Murree groups, as well as quartzite, crystalline, or trappoid pebbles, are again met with. Fossil bones become locally more numerous, the upper part of this sub-division having furnished the larger number and most of the remarkable Siwalik forms found by Mr. Theobald in this district.

The Siwalik fauna has been long well known; still, as some of the forms from this region are new or otherwise interesting, I extract, from such published sources as are available, a short list of the names of fossils found in the district, with references to the sources of the information.

Major Vicary discovered bones and an *Elephas* or *Mastodon* tusk in the Lower Siwalik beds now traversed by the Trunk Road south of Ráwalpindi (1 of List, au. cit.).

Determined by Dr. Falconer, from near "Jalálpur and Lehri," 1854 (5 of List, au. cit.):

*Elephas*, probably *E. hysudricus*.
*Mastodon*, species indeterminable.
*Hippopotamus*, resembling *Tetraprotodon*.
*Rhinoceros*, molars in fragments.
*Equus*, 2 species upper and lower molars.
*Sus*, upper jaw.
*Sivatherium*, lower jaw fragment with tooth.
*Bos*, upper and lower molars.
*Cervus* and *Antelope*, several species.
*Camelus*, portion of molar.
AVES, *Grallæ*, fragment of leg-bone.
*Crocodilus* and *Leptorhynchus* (*Gavialis*), vertebræ jaws, teeth.
*Trionyx*, carapace and vertebræ fragments.
*Fish*, a vertebra.

Determined by Mr. Lydekker from the Khareán hills, south-east corner of map, 1874 (No. 21 of List, au. cit.):—

*Equus Sivalensis*.
*Equus*.
*Bos*.
*Cervus*.
*Elephas hysudricus*.
*E. insignis* (?) *Ganesa* (?)
*Crocodilus*.

Recorded by Mr. Lydekker from the district, Asnot, &c., 1876 (Rec., IX, 3, 4, Pal. Ind.,—see List): —

*Tetraconodon magnum*, Falc.
An ear-bone of a *Cetacean*.
*Listriodon* and *Acerotherium*.
*Bos*, 4 new species.
*Rhinoceros*.
*Lutra*.
*Hydaspidotherium megacephalum*, n. g.
*Dorcatherium*.
*Camelopardalis Sivalensis*.
*Merycopotamus Sivalensis*.
*Ursitaxus Sivalensis*.
*Hyæna Sivalensis*.
*Felis*.
*Ursus*.

Determined by Mr. Theobald from south-west of Jand: *Bellia Sivalensis*, n. sp. 1877 (4 of List, au. cit.)

Besides these, many specimens await examination, amongst them the compressed shells of a fresh-water Mollusc (*Unio*) which I found in numbers at one locality (Saloi, south-by-east from Kahúta) in the upper portion of the group associated with crocodilian scutes, &c.*

Among the upper beds, but not with sufficient persistence to be everywhere distinguishable, is a thick zone of grey sandstones with few clay layers, generally of light drab or grey colour, and weathering so as to show elongated cores of harder nature than the rest. This has been called by Dr. Waagen and myself "the Dangót sandstone," from the lofty cliff of that name on the Indus near Kálabágh, in which it is conspicuous. There and in other

* *Unio* shells were also found many years ago by Mr. Theobald near Mount Tilla, at a spot which he has been unable to re-discover.

places it appears as nearly the highest band of the group underlaid by soft grey sandstones and brown or bright orange clays, but further to the east similar rocks to these overlie it. This sandstone usually contains scattered pebbles, or strings of pebbles, of quartzite, &c.; and where the overlying orange and grey rocks do not interrupt, it passes upwards by increase of the pebbles into the conglomerates of the highest tertiary group. Sections of 2,000 feet entirely formed of it have been met with. Mammalian bones occur but are not numerous in the Dangót sandstone. Similar thick sandstones, occupying the same general position, are found at the Jhelum side of the district, and the pebbly upper portion of the Lower Siwaliks seems to be most developed towards the eastern and western limits of the Potwár country.

Thicknesses of 4,000, 6,000 and 11,000 feet have been observed in this Lower Siwalik group.

### *Upper Siwalik.*

This division includes the great conglomerates and associated beds which terminate the tertiary series of the country. Like all such deposits, these conglomerates are inconstant, admitting intercalations of the same kinds of soft grey sandstones and grey or orange clays as underlie them. Besides these, highly ferruginous and occasionally bright red clay bands appear. The conglomerate is in greatest force near the large rivers, as at Salgráon on the Jhelum, at Makad on the Indus, and forming the cliffs called Káflirkot between the Kurram and Bahádur Khel. The enclosed pebbles and boulders, ranging up to 18 inches in diameter, are almost entirely of metamorphic and igneous rocks, forming an extremely varied assemblage,* the mainly Himalayan source of which is indicated by the same detritus being still carried downwards in the channel of the Indus. Amongst these pebbles a fluctuating percentage of limestone occurs, some belonging to the Silurian (?), triassic, Jura, and hill-nummulitic beds of northern regions, and some few towards the Indus to *Alveolina* or coral-bearing rocks, supposed to have travelled from the westward. Away from the large rivers, as in the Soán Upper Siwalik basin, conglomerate beds, though less prominent, still appear, sometimes formed of limestone pebbles from the ranges to the north, or where the transported fragments are fewer, these include sandstone pebbles presumably derived from the Murree group.

* For the advantage of obtaining the newest European names of some of these pebbles, I submitted duplicates of a quarter of a hundred to my friend Mr. Kinahan as an authority on the subject of rock names. The following are their designations according to him, quartzites predominating.—

1. Red and grey brecciated jasper (silicified shale)
2. Black pisolitic hornstone.
3. Red and grey pisolitic quartzite.
4. Purple felstone ("euryte") with blood-red specks, white and green silicious amygdala.
5. Black compact dolerite (aphanyte).
6. Red and green blended compact "slightly ophytic" felstone.
7. Purple granular quartzite.
8. Quartzose amygdaloidal euryte.
9. Granular purplish gray quartzite.
10. Hard green felsitic amygdaloid, tufoid.
11. Green amygdaloid, white infusible amygdala.
12. Purple amygdaloid.
13. Gray and black speckled felspathic rock.

(To 13.) "These are all passage rocks between euryte and felstone, the 'Hybrid rocks' of Durocher."

14. Flesh-coloured quartzite.
15. Black hornstone with thin parallel lines of quartz (riband argillyte, silicified shale).
16. Hard purple felsitic trap (tufoid part of a euryte?)
17. Coarse granular subcrystalline quartzite.
18. Saccharoid white quartzite or "greissen"
19. Banded purple and flesh-coloured quartzite.
20. Black argillyte.
21. Olive fine-grained quartzite.
22. Flesh-coloured and green mottled silicious rock (with nests of Olivine?).
23. Compact green felstone, harder than a file.
24. Coarse flesh-coloured quartzite.
25. Fine-grained black pyritous quartzite (Itsberyte?).

These must fall very far short of all the varieties of hard rocks among the pebbles of the Siwalik conglomerates. They were collected chiefly at the Jhelum side of the district.

In some parts of the district, the Upper Siwalik conglomerate masses are replaced by clays. This occurs south of the Bakrála ridge, and thence nearly to the Jhelum in a north-westerly direction. Again, in the valley of the Soán the group is represented by a mixture of very recent-looking sandy rocks and dull reddish clays, with an occasional dark, almost carbonaceous band; and numerous layers of gravelly conglomerate, or the limestone pebble beds already mentioned. To the westward near the Indus a thick deposit of drab and pinkish clays clearly overlies the conglomerates; it has furnished the Emydine described by Mr. Theobald, and other fossils (*ante,* 4 of List). Here, too, grey soft sandstones and orange clays are so intimately associated with the characteristic conglomerates as to have taken a considerable place in the upper group.

Siwalik mammalian remains are found in this upper division less frequently than below, and they often present a rolled or worn appearance as if derived from older beds.

In these Upper Siwalik beds, measurements of 3,600, 3,700, and 5,000 feet have been estimated from sections made to scale, and observations on the ground.

It will be seen from the foregoing descriptions that while different stages can be recognised in these tertiary rocks, their boundaries are somewhat conventional. The separation of the marine nummulitic rocks as the representatives of those in other parts of India or Asia, and the recognition of one great fresh-water series succeeding, would have marked the progress of more or less regular accummulation. Some of the beds, however, being clearly in continuation with sub-divisions of regions to the east (where more definite distinction exists), I have extended the classification to this ground as far as practicable.

Upon the estimates given, the whole series presents an aggregate depth of between 25,000 and 26,000 feet, or nearly five miles, of tertiary rocks. What terrestrial changes the time represented by the successive accumulation of such vast deposits may have witnessed, is beyond consideration here.

A few sections taken across the country, to show the manner in which the rocks occur, are appended. It should be remembered that the necessity for reducing their length to suitable compass renders them very diagramatic.

*Unconformable Post-Tertiary and Superficial.*—Large tracts of this district are covered by superficial accumulations resembling the alluvium of its present great rivers; indeed, owing to the rapid fall of these they are rarely depositing streams. Ordinary alluvium does, however, occur along their banks in places, particularly near the Lower Jhelum and Upper Indus. The older alluvium or silt very frequently predominates on the higher plateau ground, often cut through by intricate "*khudderas*" so as to show the underlying rocks. Sometimes it prevails in open depressions. Nearly all of it is more or less impregnated with soda salts (*Kuller*), rendering large areas difficult of cultivation, and, by facilitating the action of rain-water, increasing the rapidity with which "*khudderas*" are formed or extended.

Its colour varies considerably below, but the upper portion is nearly always a dull pinkish drab, glistening, finely micaceous and often distinctly stratified silt, in which "*kankar*" (carbonate of lime nodules) is locally abundant. Near Jand and Sagri, the silt is locally overlaid by loose blown sand, and it is everywhere undergoing transportation to lower levels. The saline nature and stratified condition of this silt suggest an estuarine deltoid or lacustrine origin; it has only been found to contain land shells of recent species.

Before the time of the deposit just described, certain of the larger depressions in the country existed, and some, such as the Soán, Sil, and Lower Hazára valleys, were unconformably occupied by coarse pebble beds and sand or clay. These pebble beds are not, however, confined to the valleys; they rise out of that of the Soán on its northern side near Ráwalpindi, and seem to have once overspread a good deal of the country west and north-east of that station with strongly-marked unconformity. They overlie the sides of the Rotás gorge near Jhelum; occur near Nowshera on the Son-Sakesar plateau of the Salt Range; at Namal to the westward; and cap the mountain above Kálabágh on the Indus. In most cases, if not always, they are undisturbed; but rest at locally steep angles of deposition in one or two places (in the Park at Ráwalpindi, and Son plateau, Salt Range). In the Soán valley and towards Ráwalpindi the pebble-beds are chiefly formed of detritus from the limestone hills to the north, but the very layers consisting most largely of calcareous pebbles at the Pindi side of the valley, crossing the river, gradually change into a mass of light-coloured quartzite boulders, the original locality of which is as yet unknown. The unconformity so strongly marked near the Soán bridge on the Trunk Road is scarcely traceable in lower parts of this valley, though of course it exists.

In the Hazára and Chutch (Chaj) plains, the pebble rocks beneath the superficial silt, &c., appear as a coarse conglomerate or well-rounded gravel, chiefly of syenitic and gneiss fragments, overlaid by thick horizontal sands, sometimes consolidated so as to form a sandstone of almost precisely similar appearance to those of the upper tertiary beds, but enclosing subangular and rounded blocks of crystalline rock similar to the pebbles beneath.

Along the Indus and in the banks of the lower part of the Haró river these pebble and boulder beds are again seen, occupying different levels, chiefly in the lower part of the river deposits: similar post-tertiary accumulations form rather a high flat between the Mírkulán and Chíta hills, and the thick sands recur on the Indus near Sújanda.

North of the Mírkulán and Affrídi hills, detrital beds, apparently of the same group, were observed near Ispínhák, as saline yellow, pale pink, greenish, red and white sands, clays, and gravelly beds with bones,* or soft micaceous sandstone.

These coarse deposits, though not always present, seem to be transitional with the lowest layers of the silt, and this has not been observed to overlie the pebble beds in some lofty situations, where it may be doubtful that it ever was deposited.

The heights at which the post-tertiary beds are found range from about 800 to 3,000 feet above the sea; they have much the aspect of river deposits, and may have been formed at different periods.

Another variety of superficial accumulations, dating far back, though still forming, is the "wash" or "fan" detritus edging the Salt Range to the south, the hills near Banú, and those in the neighbourhood of Mírkulán and Pullosi passes towards Cherát.

Calcareous tufa ("kamát") is not an uncommon associate of the newer deposits. Sheets of it are interposed between the "pebble beds" and the underlying Murree group, upon the banks of the river Lé, near Ráwalpindi; others seem to have once overspread the ground near Fatahjang, and it is frequently seen among or near the limestone hills.

*Erratics.*—Dr. A. Verchere is believed to have first recorded the occurrence of large erratic blocks near Trap village on the Soán, attributing them to flotation by means of ice. These travelled blocks are distributed along the left bank of the Indus from Attock southwards, reaching into the country for ten or twelve miles from the river. They are more numerous between the parallels of Attock and Jand than further to the south, strewing the surface of the ground in patches, some being partially buried in the sand or other superficial accumulations.

* Major Vicary found the bone of a camel (?) in apparently the same beds at Akhora (au. cit.).

A group of these erratics occurs on the road between Jand and Kushálgarh; one is of granite, measuring over 15 feet by 9 feet by 3 feet (exposed). Others close by are of syenite, gneiss, hornblend schist, and black slate. For a few hundred yards around the ground is dotted with similar and smaller blocks, and others are numerously distributed over the neighbouring sandy country. Some of these appeared smoothed, but none that I saw showed any signs of striation.

Near the Tútal or Rais river opposite to Jand erratics occur again, but fewer. One of grey syenite measured 4 feet by 2 feet by 2 feet 2 inches; and a block of grey gypsum, 18 inches by 12 inches, was precisely of the kind occurring beyond the Indus in the Gúrgúrlot and other hills, or at Báhtar on the left bank of the river, where it crosses the Chíta range.

Two large erratics lie near the hamlet of Kummerallia (Wahlia of the maps) south of Daknér: one of white granitoid rock, weathering dark, has a girth of 50 feet and a height of 6 to 8 feet; the other, of basalt, is 48 feet 6 inches in girth and 12 feet 6 inches high. A block of grey felsite, set on end in the sand half a mile south of Hatti on the Trunk Road, forms a conspicuous monolith: it measures 8 feet 6 inches high by 18 inches by 6 to 10 inches. Not far to the north is a block of the Kyjnág and Hazára porphyritic granite with large twin crystals of felspar; it has dimensions of 9 feet by 3 feet 6 inches, and is much buried. There are others scattered about, but this one only suggests the northern source of these erratics with some certainty and the Indus valley as the direction from which they travelled.*

Far to the south-east near Hoon, Mount Tilla, Rotás, and in the Bunhár river at Ghoragali, smaller and less angular erratic blocks of red granite are numerous. One of these, however, at Narwari, a mile east of the Collector's bungalow at the Mayo salt mines (Khewra), is 7 feet in height, measures 15 feet in circumference at the ground, 19 feet half-way up,† and rests upon the red gypseous marl. These red crystalline boulders are supposed to have come from a peculiar conglomerate in the cretaceous or "olive group" of the Eastern Salt Range, or at least from the same unknown source as its enclosed blocks. One such boulder, polished and striated, apparently by glacial action, was shown me by Mr. Theobald, who found it in a wall near Wahali, on the eastern plateau of the Salt Range, not far from where the conglomerate just mentioned is *in situ*.

By what means these erratics were transported, if not by the agency of ice, is unknown. Their size, sub-angular shape, and the distances they must have travelled, favor this supposition. All do not seem to have wandered so much, thus localising the transporting cause: on one of the river terraces of the Indus gorge between Purri and Báhtar, I measured an erratic mass of unfossiliferous limestone 9 feet high and 74 feet in girth, which may have belonged to any of the neighbouring limestones from the lower nummulitic downwards, and seems to be as truly an erratic block as any of the others.

With regard to the existence of a glacial period affecting the Upper Punjáb in very recent geological times, the only evidence the country seems to offer is in the occurrence of the formerly Indus-borne crystalline fragments at heights some 2,000 feet above the present bed of the river. These would indicate either a very late elevation of the region traversed by the Indus, or that when it ran in a channel so much higher, the hilly country to the northward may have been as much more lofty (or even higher still), and regions of perennial snow much nearer than they are at present. The denudation, which, influenced by earth-movements, or alone, reduced the general surface, would have removed most evidences of

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* I have also noted granite and other crystalline erratics at heights of four or five hundred feet above the Jhelum near Chuttur Kalas, the first stage from Kohála or the new road into Kashmír.

† From measurements kindly furnished by Dr. Warth.

glacial action,* and the widely spread, well-stratified post-tertiary silt would indicate aqueous conditions in the vicinity, which might have facilitated the distribution of these erratic blocks.

### SUPPORTING ROCKS OF THE TERTIARY ZONE.

I shall now endeavour to convey as briefly as possible some slight idea of the palæozoic and mesozoic formations bordering the tertiary zone in this district.

### SOUTHERN OR SALT-RANGE ROCKS.

The nine Salt Range groups of palæozoic and mesozoic formations, included in the list (*ante* p. 113) exhibit parallelism and conformity throughout; this, however, may be only a local, yet marked, peculiarity. Another as great is that the strata composing the sections at either end of the range are strikingly dissimilar. One formation or group may be traced thinning away and becoming overlapped by another at various points along it, so that in no place is the full section obtainable. Besides this the whole region has undergone most violent disturbance, resulting in displacement and contortion, sometimes one or both being prominent, and in places, owing to this, the oldest and newest of the groups are brought into contact. The outcrop on the scarped side of the range is thrown frequently into such intense confusion from land-slips caused by the deliquescent nature of the salt-marl that it is difficult to reproduce it on any map, and entirely impossible on the roughly reduced outline given with this paper.

"*Saline Series.*"—The red marl, gypsum, and rock-salt forming the lowest group is as mysterious in its origin as strange in its development and economically important, producing a large annual revenue of about £400,000 sterling. The salt occurs in the upper portion of a mass of red gypseous marl, and underlies massive, white, stratified gypsum. It shows a thickness of 600 feet at the Mayo mines, of which 225 are almost chemically pure salt (Dr. Warth's paper, No. 11 of list).

"*Purple Sandstone.*"—Thick sandstones, earthy below and of deep purple colour, becoming whitish at top, succeed the saline series. This "purple group" extends far to the west, but there becomes thin, and the sandstones give place to dark earthy conglomerates containing crystalline boulders of red granite and other rocks. It contains no fossils, so far as known.

"*Obolus beds.*"—In the next formation, however (also ranging widely westward), a belt of blackish clunchy shale, with sandy layers, was found to contain, at one or two places, the small detached valves of *Obolus* or *Siphonotreta*, a Silurian form, locally numerous, but entirely by themselves.

"*Magnesian Sandstones.*"—This group is to the east succeeded by, and connected with, a strong lightly coloured set of beds, the most conspicuous of which are hard, compact, magnesian layers, varying from dolomite to magnesian sandstone, and associated with flaggy and darker shaly bands, often covered with fucoidal and annelid markings. This formation has a more limited extension than the last, and was doubtfully thought by Dr. Waagen possibly to represent the carboniferous limestone of the west. From its position in certain sections, it appears to underlie that group, so I have preferred to keep it provisionally separate, particularly on account of its partial intercalation with the zone below, just where it is least recognisable to the westward.

"*Speckled Sandstone.*"—The next group is a massive succession of speckled light-coloured or reddish sandstones, with purple clays and conglomerate bands, the pebbles of which are chiefly of old crystalline rocks. At the top of the group, pale lavender clays (said to contain small concretions of copper pyrites) are constantly present.

* As pointed out by Mr. Croll would generally be the case (Climate and Time).

"*Carboniferous.*"—Immediately above these layers the carboniferous series commences in the Nilwán ravine, as dull, dark-coloured, impure, calcareous beds of small thickness. Westward the formation developes rapidly into a great mass of clear limestones, with some ferruginous or pale sandstones and dark earthy calcareous layers, the whole often crowded with palæozoic fossils, amongst which Dr. Waagen found the unique carboniferous *Ammonites* which he has described (*l. c.* No. 9 of list).

"*Triassic.*"—Almost united lithologically with this group is a series of thin limestones and greenish shales or clays developed from the Son plateau of the range westward, and containing abundance of *Ceratites*, *Goniatites*, and other forms, of the same genera but of different species from those in the carboniferous group below (as distinguished by Dr. Waagen). On the evidence afforded by these a triassic age has been assigned for the group, to which period also a group of bright red arenaceous and argillaceous rocks in the east part of the range, without fossils, but full of casts of salt-crystals, has been referred. It immediately succeeds the magnesian group before mentioned.

"*Jurassic.*"—Overlying the western triassic group are white soft sandstones, yellowish limestones, oolitic and earthy beds containing *Belemnites*, more rarely *Ammonites*, and other Jurassic fossils. The upper part of this Jurassic group becomes dark and shaly Trans-Indus at the Chicháli pass, where a curiously inverted and faulted section is exposed. Along their Western Salt Range boundary, the uppermost Jurassic and lowest nummulitic rocks present appearances of local transition through alternating bands of limestone, sandstone, and shale.

"*Cretaceous.*"—In some places, however, as in the eastern part of the range and at the Chicháli pass, dark-coloured shales and olive or yellowish sandstone with local beds of peculiar dark conglomeratic clay intervene between the above-named groups, or between the red trias (?) of the east and the coaly, shaly, ferruginous, or white sandy beds near the local base of the nummulitic formation. The shales in the Chicháli pass contain several globose *Ammonites*, recognised at once by Dr. Waagen as cretaceous; and I have found in these intervening beds (to the east) casts of large shells, which, with a few forms discovered by Dr. Waagen near Makrách, led to suggest for the beds a cretaceous age.

From the salt marl upwards, all the formations, as far as the base of the tertiary, seem to be marine; but as some are not fossiliferous, and there is a record of some plants found in the Jurassic group by Dr. Fleming, this is less than absolutely certain.

It will be seen that the contrast is strong between the rocks of this area and the pre-tertiary series of the outer Himalayan region.

### WESTERN PUNJÁB, HIMALAYAN SERIES.

"*Crystalline.*"—The oldest part of this series includes the syenitic rocks, granitoid porphyry, and greenstones of Hazára (Pakli valley, Súsúlgali Agrór, &c.), and, from specimens brought down, it seems that crystalline rocks are common in Kaghán also. The granitic porphyry with its twin crystals of felspar, 5 or 6 inches high, is exactly like that occurring as erratic masses (from the Kyjnág range, &c.) near Nowshera in the Jhelum valley on the road from Murree to Kashmír.*

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* This porphyritic rock seems to represent the central gneiss of Dr. Stoliczka's Himalayan sections (Mem. Geol. Surv. Vol. V); at least he appeared to identify a block we found together in the Jhelum at Huttí, Kashmír, with his "Albite granite."

"*Metamorphic and Silurian.*"—Over a considerable area outside the Hazára granitoid rocks, slightly metamorphosed, dull, talcose, silky slates were traversed, representing the local "Attock slates" of Nowshéra, Abbottabád, &c. Some of the altered beds (on the road from Manséra to Garhi Habibúlla, for instance) weather to a substance resembling porcelain clay. Greenstone dykes and masses intersect the inner portion of the slates, and syenitic protrusions occur, but no stratified or foliated gneiss nor any mass of quartzites or mica schists was met with, though such were known to Dr. Fleming among these mountains, probably at places which I did not visit.

In the Upper Hazára slates and those of Mianjáni mountain limestones are absent or uncommon, but occur extensively in the Gandgarh mountain north of Hassan Abdál, in the Attock hills and towards Mírkulán. These limestone bands have varied textures, from pseudo-brecciated to compact, and are often magnesian: one remarkable bed, though unaccompanied by other local metamorphism, resembles a clear sub-crystalline and compact white altered marble; it is slightly affected by acid. It stretches along the southern face of the Attock and Mírkulán hills. It is not improbable that several of these limestones, though closely associated with the dark slates, do not belong exactly to that series, but to some newer group. Others are undoubtedly interstratified.

In none of the slates or intercalated limestones have I been able to find a single organism; but in the hard limestones near Dakner, I found obscure traces of small gastropods and other shells, barely recognisable as organic: further west, at Mírkulán pass, these traces are stronger, and a few fossils can be distinguished.

The stratification of the slates is often obscured by a number of cross-cleavages, which render their furnishing slate of economic value unlikely. As a rule, they are very thinly laminated, this structure enabling slab or bedding slates to be raised where the cleavage is less prominent or coincides with the bedding; the material, however, is soft and weathers easily. Bands of dark-greenish, gritty, fine-grained sandstone are not uncommon. The whole group often shows intense folding and compression.

A possibly Silurian age for these slates has been chiefly inferred from the discovery of Silurian fossils by Dr. Falconer and Major Vicary in the Peshawar district, apparently not *in situ*, but traced to the Khyber mountains in Afghánistán. These fossils are stated to have been of lower Silurian age. Major Vicary mentions *Spirifer*, *Orthis*, *Terebratula* (?) and *Polyparia* in limestone. Similar genera occurring in the carboniferous and secondary rocks of the other parts of the country, the evidence as to Silurian age is limited, so far as any information at present available extends, to Dr. Falconer's fossils, as referred to by Major Godwin-Austen (in Quar. Journ. Geol. Soc. Lond. Vol. xxii, p. 29).

The slate group is perhaps older than carboniferous,* and may be a continuation of the azoic slates of Dr. Stoliczka's Himalayan sections.

"*Infra-Triassic.*"—Resting upon the Attock slates with complete unconformity is the series of Sirban mountain in Hazára (see Memoirs, No. 12 of List). The unfossiliferous red sandstones, hæmatitic and silicious magnesian beds, there underlying the triassic formation, are of unascertained age, and have not as yet been found elsewhere.

"*Triassic.*"—The triassic formation of the whole northern region consists largely of limestones often so slightly fossiliferous as to be very difficult to distinguish from those of

* Last season Mr. Lydekker found in a detached block near Hassan Abdál a specimen of *Productus Humboldti*, common in the Salt Range carboniferous formation. I have since searched the place in vain for any evidence of the existence of carboniferous rocks in the locality. It is possible that some may occur among the limestones on the south side of Gandgarh mountain to the north, though I failed to find a fossil of any kind in the only traverse of the mountain I have as yet been able to make.

the Jurassic period. Shales, limestones, silicious breccia, hæmatitic clays, and sandstones are present at Sirban; in other places limestones only are found, or with these a few shales, a sandstone band, or some ferruginous amygdaloidal clay. In one case I observed among other limestone rocks supposed to belong to this formation, a limestone conglomerate enclosing fragments of coralline limestone. The triassic beds are in force among the hills extending from the Mochpúra mountains to the Trunk Road; and a quantity of hard limestone, much of which may be triassic, appears in the Chíta range as well as in the detached hills to the north.

The fossils of the formation are, as a rule, scarce, obscure, and hard to detach: *Nerinæa, Neritopsis, Astarte, Opis, Nuculæ, Ledæ, Ostreæ, Terebratulæ, Rhynchonellæ, Megalodon, Dicerocardium, Chemnitzia* and *Gervillia* were identified by Dr. Waagen at Sirban, and *Ostrea Haidingeri* near Khairagali. At the western base of the Zyarut hill at Hassan Abdál I found a massive grey limestone bed unconformable upon Attock slates, and full of large *Dicerocardium* (and *Gervillia ?*) sections, the fossils being impacted and impossible to separate. Overlying this is a large zone of hard, thin-bedded limestones from which I obtained (loose) a very perfect *Pholadomya*. Sections of *Rhynchonellæ* are seen in the rocks, and on close search little *Retzia* ( ? ) and Echinoderms are found weathered out. If the fossils of the upper portion of these limestones prove Jurassic, the unconformity between the trias and Jura of Sirban is absent here.

Thick, amorphous, splintery, nummulitic limestone of the paler hill-type caps the whole, and is compressed between the folds of the older beds, with very doubtful conformity to the thinner limestones below. In another section, near Kamalpur, of similar hard, thin-bedded limestone with some thicker bands, is a layer crowded with very large and thick *Ostreæ*.

The complicated association of limestones, trias, Jura, and nummulitic, extends westwards further than it can be followed into Affrídi territory (Afghánistán). "Large fossil oysters" are reported from a stream near Cherát, and at Mírkulán, not far from this place, there is the following succession, from south to north, a considerable part of which may be triassic:

*Mírkulán Section.*

(*North.*)

30. Dark Attock slates, with some harder bands.
    Fault (?).
    *Upper Nummulitic.*
29. Bright red earthy rocks and soft greenish sandstone.
28. Sandy limestone with large quartz grains.
27. Olive shales.
26. Strong purple sandstones.
25. Very red earthy rocks, cleaved.
24. Grey, slaty, olive and greenish shale, cleaved parts full of *nummulites*.
    *Cretaceous* (?).
23. Alternations of slaty shale and dark limestone with sections of *Cerithium* and *Natica* (?). Calcareous bands weathered to a rusty clay full of undeterminable fossils.

22. Thick limestone.
21. Dark greyish-green, slaty band.
20. Thin dark, flaggy limestones.
19. Greenish and grey limestones, highly contorted.
18. Thin-bedded black limestone.

17. Dark grey quartzite, with black flaggy slate bands, and white flaggy calcareous layers (600 ft.).
16. Silicious gritty beds.
15. Grey and purplish, rippled, thick-bedded slate (1,500 ft.?).
14. Grey, purple, and greenish flaggy limestone.
13. Dark green calcareous slates, thinly laminated.
12. White flaggy limestone with yellow lines, among grey slaty beds.
11. Dark grey and variegated limestone, magnesian, compact, with ferruginous strings; a black earthy layer and several shale partings, one hard blue band crowded with sections of thin flat bivalves, shelly parts often oolitic. and contain sections of pentagonal crinoid stems.
10. Purple slaty band.
9. Black and greenish shining shale or clay, flaky; layers and nodules of grey oolitic limestone.
8. Black limestone—dolomitic in places, then of brownish grey colour.
7. Green-olive fine slate.
6. Strong grey and variegated yellow and black limestone: no fossils.
5. Brownish grey and purple slaty band, passing up into yellowish and green calcareous slate (about 200 ft.).
4. White flaggy lithographic limestone, thin and flaggy above, alternating with grey bands, like Solenhofen lithographic slate, upper part lavender-coloured.
3. Greenish olive; dark, shaly ferruginous, thin band (same as "Darwáza" limestone on Indus near Dakner).
2. Brownish yellow brecciated limestone, overlying.
1. Olive shales with ferruginous concretions.

The correlation of this section cannot be usefully attempted till the ground has received further examination. The series appears to rise in the direction indicated by the progressive numbers, but may be affected by faults and inversion in part. The southern end would seem to belong to the slate series; further on, the only guess which Dr. Waagen could hazard from the imperfect organisms found, was that the zone (so marked in the section) might be cretaceous; while the upper part, presumably faulted against the slates, is certainly nummulitic and perhaps upper nummulitic. The thickness exposed must be great, but could only be estimated for some of the zones.

"*Jurassic.*"—Jurassic rocks are known to exist in many places beneath the lower nummulitic beds. They, too, are chiefly limestones and not of widely different aspect from those overlying. In the southerly parts of these northern hills they usually contain a well-marked rusty zone, enclosing small grains of quartz, which give a rough appearance to the weathered surface of the rock. This zone is sometimes a mass of fossils, chiefly of large *Trigonia ventricosa,** of which the matted and intertangled casts can only be obtained. *T. costata* occurs also, but the sections of the larger species give a very marked character to the weathered surface of the rock.

In the hills near Márgala pass, where broken portions of the Trigonia rock occur, the associated beds contain fragments of *Ammonites* and *Belemnites*. Again, to the west near Jang, the latter and *Gryphæa* abound in one or two layers just below the Trigonia bed. *Ammonites* of well-known Himalayan forms† are numerous in the Spiti shales of Chamba

* Determined by Dr. Feistmantel.

† *Oppelia acucincta*, Strachey, *Perisphinctes frequens* Opp.† conf. *Simplex*, Sow., *Belemnites Gerardi* Opp. *Inoceramus*, *Cuculæa* and *Pecten* are the fossils mentioned by Dr. Waagen. Records, G. S. I., Vol. V, para. 1, p. 17.

peak near Khairagali (where they were first discovered by Dr. Beveridge, R.A.). *Inoceramus* and *Ammonites* fragments, a *Pecten* and *Belemnites*, occur in another exposure of the Spiti group at Kondragali on the Abbottabád upper road from Murree; and some of these fossils re-appear in dark-coloured sandy and calcareous rocks far down in the deep ravine of the Haró below this locality.

None of these Jurassic rocks, Spiti shales, *Trigonia* zone, or the harder compact and semi-lithographic limestones in the least resemble the Salt Range Jurassic rocks, nor is there any similarity between the great trias limestones, &c., of the northern region and the *Ceratite* beds of the other locality. The cretaceous horizon of the northern area is chiefly marked by hard sandy limestones forming a thin band at Sirban and in the hills close to Kohát (though thicker limestones without fossils may also belong to the same formation). This band contains several *Ammonites*, a few *Baculites* and large *Belemnites*, generally of uncanaliculate forms. The aspect of the band is also quite unlike the dark shales of Chicháli or the "olive group" of the Salt Range.

Palæontological skill only can decide how far the northern and southern fauna are disimilar; to ordinary observation there is a striking difference between the fossils belonging to the formations of all ages from the two areas, corresponding with the lithological diversity, and suggesting much variation of conditions during palæozoic and subsequent times.

## DISTURBANCE.

There are abundant instances of most intense disturbance and dislocation in this district, yet they appear to have resulted from but one extended influence, which produced the whole system of its mountain features. Strata belonging to all periods older than post-tertiary are contorted, but as no chronological sequence can be distinguished amongst the countless folds or numerous faults in any of the series, the whole of the disturbance connected with the physical features can only be attributed to a post-Siwalik period. Whether the results are due to one prolonged or to consecutive exertions of force, there is as little to indicate, as there is to show when the action ceased.

The marked line of disturbance, dislocation, and inversion along the outer Himalayan limestone hills has no counterpart in the district (unless a concealed feature of similar kind skirts the Salt Range on the south). It appears to imply special intensity of the disturbing agency. Other developments of extreme results occur;—a complete inversion of the Jurassic and tertiary limestones is seen among the hills between Shaladitta and Khánpur (northward of Ráwalpindi): inversion is common, sometimes extraordinary, all over the Kohát country, and its presence at Chicháli pass has long been known.

Although whole ages of apparently tranquil accumulation distinguish the succession in the Salt Range, the limitation laterally of so many of its groups may have been connected with slight or local alterations of level.

In the Himalayan area there are traces of palæozoic and mesozoic elevations and denudations, in the unconformities mentioned (at Sirban and Hassan Abdál), however local these may have been; and in the more central area, similar events in tertiary times are indicated by the derived fragments enclosed in the rocks.

The presence of the great tertiary sandstone and clay series of this area asserts the previous existence of an elevated region to the north, and its Siwalik boulder beds point to a west Himalayan elevation in later tertiary times, as plainly as the distribution of the same boulders in subsequent deposits proves that those western Himalayan regions have remained elevated ever since.

The lofty situations of these Himalayan boulders in some localities may either indicate a post-tertiary elevation or be a measure for part of the sub-aëreal denudation of the Upper Punjáb.

## Description of the Figured Sections.

These three sections, in consequence of the vertical exaggeration necessary, will show at a glance the general fall of the country towards the Indus from the Murree hills and Salt Range.

It will also be seen that the Himalayan side of the Ráwalpindi plateau is much the most generally disturbed, the folding of the rocks being almost confined in its greatest intensity to the Náhan-Sirmúr band and those groups lying northward of it. The local character of the Salt Range disturbances will also appear, but the sections do not happen to cross where these are most developed.

Section No. 1 is in two parts, from the difficulty of taking a single line over the most expressive features of the ground. In the part of it along the Trunk Road it may be noticed that the upper Siwalik conglomerates at and near the Rotás anticlinal are represented in the Kharián hills and south of the Bakrála ridge by clays. The faulting at the latter locality might be supposed sufficient to account for this, but from the aspect of the neighbouring country it appears equally probable that the formation has changed and the coarser beds have been replaced as at the Kharián ridge. The Náhan beds of Bakrála ridge have been already referred to.

The lower Siwaliks are largely developed from Mount Narh to the southward, giving sections of over 13,500 feet; and the upper Siwalik conglomerate beds have a thickness of 2,800 feet at Salgráon. The Murree hills are all formed of the rocks referred to the Náhan-Sirmúr group, but the contortion is so great that their thickness can only be guessed at about 5,000 to 7,000 feet, with the probability of its being very much greater.

The whole of the Kuldana spur, uniting the Murree ridge with the more lofty ranges to the north, is occupied by upper nummulitic beds, including a quantity of sandstones, &c., so similar to the overlying ones that their identity has been doubted. If the faulting necessary to have produced the present arrangement could be accounted for in detail, these questionable beds might be admitted to have belonged to the series above.

Northward from Kuldana the section has been already described, and its continuation to beyond the Miánjáni slates near Batangi shows alternation of nummulitic and Jurassic or triassic exposures, crushed and faulted beyond recognition of the geological relations. The mass of red rocks at Dungagali are believed to be upper nummulitic beds introduced by faults.

Section No. 2.—From Pind Dádun Khán to Gandgarh (or from the Jhelum to the Indus).—In this section one of the most conspicuous faults of the Eastern Salt Range is crossed, bringing a portion of the tertiary Náhan beds against the lower rocks of the palæozoic series. The land-slips and complexities of the Salt Range section here had to be omitted on account of the reduced scale of the section. North of the range the beds having most the appearance of the Náhan rocks may be taken at 1,500 feet, but beyond this the wide expansion of the lower Siwaliks rolling at gentle angles conveys little idea of the true thickness of the beds—a large one, however, in all probability exceeding 10,000 feet. The upper Siwaliks of the Soán basin may be estimated at from 300 to 500 feet, and are generally overlaid by the valley-deposits or loess, both series being in places so horizontal and so similar as to be hardly distinguishable. At the northern side of this basin the beds become gradually tilted; the gravelly conglomeratic beds and clays pass down into the red and gray rocks of the lower group to near Khaire-Múrut ridge, where the angles are very highly inclined, or vertical bedding is found in the purple Náhan-Sirmúr group. In places on both sides of this ridge there are traces of the upper nummulitic beds intervening between the limestone of the hill and the purple rocks on its flanks, but the junction on either side as frequently has the appearance of a fault. Hence to the vicinity of Fatahjang numberless steep inclinations towards the north and south in the Náhan-Sirmúr rocks indicate the closely-folded and compressed curves of the beds, which are both disturbed and displaced at the upper nummulitic zone, as may be seen where the alternating limestones, shales, &c., mark the arrangement more distinctly. As an example of the contortion here I may mention that *thirteen* anticlinal curvatures are shown within 3,000 feet horizontally in one of Mr. Lyman's very carefully detailed sections at the Fatahjang petroleum springs, and there are many similar cases.

It not unfrequently occurs along the junction of the upper nummulitic zone with the stronger limestones of the adjacent hills, that there is a small space between the two occupied by rocks resembling those outside that zone. This is sometimes due to combined faulting and inversion, but the contortion is often so great that it is difficult to say whether there are not some intervening red and purple sandstones and clays really present. Sometimes also there are but very few layers of the well-developed upper nummulitic character to be found in their usual position, as at Shaladitta, where the main zone is a mile and a half to the southward, and the usual lower sandstones and clays of the Náhan-Sirmúr group, containing occasional layers of upper nummulitic type, are *faulted against*, rather than rest on, the Jurassic limestone of the hills.*

In this section (No. 2) the solid limestones of the Chíta Pahár range are of unusually pale colour, and sometimes full of nummulites. At the northern base of the range they are in contact with a highly disturbed and faulted zone of upper nummulitic beds. Further north the rocks beneath are concealed by heavy accumulation of valley beds (syenitic gravel and gray sands), until at Khaire Múrut the hard triassic-looking limestones show themselves in a folded state capped by and faulted against nummulitic limestone, below which the *Dicerocardium* and overlying limestones (some of them Jurassic?) of Hassan Abdál rest upon slightly exposed Attock slates, such as are seen with many intercalated and associated limestone masses on Gandgarh to the north.

In section No. 3 the carboniferous limestone of the Salt Range is shown appearing thicker than it is on account of the vertical exaggeration. The groups below it are the "speckled sandstone," "purple sandstone," and "gypseous" salt-bearing series, while the mesozoic formations above include the triassic Ceratite beds and Jurassic sandstones and limestones overlaid by the strong nummulitic limestone. The section continues through the same series as before, traversing the great upper Siwalik conglomerates of the Mokud region, the slightly fossiliferous bone and wood-bearing rocks of Jand and Nara, the upper nummulitic limestone and secondary limestones (probably both trias and Jura) of the Chíta range, then turning eastward in the river Indus traverses the valley deposits of the Kamalpur plains and the slates and limestones of the Attock hills, as shown in the section.

* Compare Records, Vol. IX, p. 156, para. 3.

NOTES ON FOSSIL FLORAS IN INDIA, *by* OTTOKAR FEISTMANTEL, M.D., *Palæontologist, Geological Survey of India.*

## XIV, XV, XVI.

### XIV.—ON A TREE FERN STEM FROM THE CRETACEOUS ROCKS NEAR TRICHINOPOLY IN SOUTHERN INDIA. (*With Plate.*)

AMONGST the fossil plants in the collections of the Geological Survey there is a portion of a tree fern stem from Trichinopoly, collected by Mr. H. F. Blanford from the same strata with the marine animal remains which yielded the numerous material for Dr. Stoliczka's monographs on the history of these fossils. Forms of the same kind have as yet been found mostly in cretaceous rocks at several pretty distant localities, on almost the same horizon, so that, if there were no information about our specimen, one might conjecture its being of cretaceous age.

If we look through the literature, we find (not regarding the carboniferous *Megaphytum* and *Caulopteris,* which have different characters) fern trees of this kind, first described and figured from Kaunic in Bohemia, by Comte Kaspar Sternberg*). This illustrous author, however, not knowing well the relations of the locality, and not knowing at that time any of the fossils which were later found associated with these stems, described them from the disposition of the scars and from their superficial resemblance with some stems of *Lepidodendron* and *Sagenaria,* as *Lepidod. punctatum,* Sternb., and the locality Kaunic as belonging to the carboniferous formation. Brongniart† described it even as *Sigillaria,* and also as carboniferous.

Prof. Göppert, 1836,‡ was the first to describe it as a fern, but placed it with the genus *Caulopteris,* species of which genus occur mostly in carboniferous strata. The same author described another species as *Caulopteris Singeri* from Silesia, which he later, however, united with that Bohemian species.

Presl, 1838, in Sternberg's *Flora der Vorwelt,* placed it with *Protopteris* as *Protopt. punctata,* and consequently the *Caulopteris Singeri,* Gopp., was also placed with *Protopteris.*

Corda § changed also the specific name to *Protopteris Sternbergi,* considering the locality, however, also as carboniferous (1845).

But soon after this, already in 1852, Prof. Reuss || mentioned that Kaunic does not belong to carboniferous, but is cretaceous, which in the subsequent year (1853) was quite distinctly shown by Prof. Krejci ¶ of Prague, who examined the locality, and proved that the sandstone wherein the *Protopteris Sternbergi* (*punctata*) was found is not carboniferous but cretaceous (cenoman.); he found again some stems of the same species, and also two new forms, of which one was named *Alsophilina Kaunitziana,* Dorm., and the other *Oncopteris Nettwalli,* Dorm., and figures of both were given with his paper, all being cretaceous.

In 1869 the same author** published an exhaustive report on the stratigraphical relations of the cretaceous formation in Bohemia, wherein, on pages 46 and 88-89, *Protopteris*

* Versuch einer Flora der Vorwelt, I. fasc. 1, p. 19, tab. iv. f. i. viii. 2.

† Histoire de végét. fossil p. 421, tab. 141, f. i.

‡ System. filic. fossil, 1836, p. 449.

§ Corda Beiträge zur Flora der Vorwelt, 1845,

|| Jahrb. d. K. K. Geol. Reichsanst, Vol. III, n. 2, p. 105.

¶ Kounická Skála, in "Ziva," 1853.

** Archiv f. naturw. Durchforchung von Böhmen; geol. Sektion, 1Bd. Studien im Gebiete d. Böhm. ] formation.

*Sternbergi*, Cord. (or *Caulopteris punctata*, Gopp.) is clearly described as from the lowest strata of the cretaceous rocks, the so-called Perutz-beds, near Kaunic and Vyserovic, so that there could no longer exist any doubt about it. Prof. Krejci did not, however, mention any fossils from the clays associated with the sandstones.

When in 1870 I joined the party for the geological exploration of Bohemia, I visited several localities in these lowest plant-bearing strata of the cretaceous rocks, especially the localities Nehvizd, Vyserovic, and Kaunic, east of Prague, and I saw the sandstone containing the fern stems intercalated with clay bands, in which were numerous plant-remains, consisting of some fern fronds, some coniferous branches, but especially *dicotyledonous* leaves, amongst which the peculiar genus *Credneria*, a typical cretaceous genus, was very frequent; in general the fossils agreed mostly with those described by Prof. Heer from Moletin in Moravia, and with those from Niederschöna in Saxony (as far as they are known), both which localities, as well as those in Bohemia, belong to the cenomanian; thus it was quite plain that *Protopteris Sternbergi*, Cord. (*Lepidodendron punctatum*, Stbg.), was a cretaceous tree-fern.

Also Prof. Römer in his *Geologie von Oberschlesien*, 1870, describes *Protopteris Sternbergi*, Cord., as distinctly cretaceous.

Subsequently, in my monograph on fossil tree-ferns from Bohemia* (carboniferous, permian, and cretaceous), I described the relations of these beds near Kaunic, which contain he *Protopteris Sternbergi*, and are cenomanian.

Previously to this Prof Göppert† had twice shown that *Protopteris Sternbergi* is cenoman, and placed his *Caulopteris Singeri* with it.

Prof. Heer in 1874 seems still to have known only the older descriptions of this fern as carboniferous, so that in his third volume of the *Flora Fossils Arctica* the locality Ujarasusuk of Disco in Greenland is described, from the occurrence of this *Protopteris Sternbergi*, as belonging to the carboniferous formation; but in a preface to the work he mentions a letter of mine to him on the occurrence of *Protopteris* in Bohemia, and then refers correctly the fern stem from Greenland to the cretaceous formation.

In Schimper's *Pal. végétale*, 1869-74, we find *Protopteris Sternbergi* still quoted as from carboniferous.

Its true horizon has been, however, fully confirmed also in other countries; the same fern was found in cretaceous (Unter Quader—Cenoman) of Saxony; ‡ and Mr. Carruthers § described it from the Upper Greensand in England (Shaftesbury in Dorsetshire), distinctly saying, on p. 485, that Dr. Fritsch of Prague has informed him that the beds from which *Caulopteris punctata* was obtained are Upper Greensand (cenoman).

In 1867 Prof. Unger || described a very nice fern stem from the cretaceous (Neocomian) near Ischl in Austria, to which our form from Trichinopoly is mostly allied. But Unger also was at that time quite unacquainted both with Prof. Krejci's publications about the tree ferns in Bohemia (1853), and with Carruthers' description of the same species from the English Upper Greensand, for he says, on page 648, that the Ischl species would be the first tree-fern in the cretaceous formation.

* Abhandl. d. K. böhm. Gesellsch. d. Wissensch. 1872, with two plates.

† Zeitschrift. d. D. Geol. Gesellsch, 1865, p. 643, and N. Jahrb. f. Min. etc, 1865, p. 396.

‡ Genitz Elbthalgebirge 1875, p. 304, Pl. 67, f. 1 (Palæontografica, Cassel).

§ Geolog. Magazine, 1865, p. 484, Pl. XIII.

|| Sitzungberichte der k. k. Acad. der Wissensch. LV, 1, 1867, p. 642, *et seq.*, Pl. I.

Quite recently I published a preliminary report on the flora of the cretaceous rocks in Bohemia,* where I speak especially in detail of the lowest beds (Perutz.-beds) near Nehvizd, Vyserovic, and Kaunic; two sections illustrate the relations, and all the species determined up to that date are given. From this report it is quite distinctly shown how *Protopteris Sternbergi*, Cord. (*punctata*), is found in the sandstone, together with other species of tree ferns, and with cones of *Damarites*,† while the intercalated clays contain other plant fossils.

These beds in Bohemia with *Protopteris* are therefore cenomanian; so are the beds in Moletin in Moravia, and near Niederschöna in Saxony; also the locality in Saxony with Protopteris is cenomanian; the English locality is cenomanian too, and the locality in Greenland was afterwards (in the preface) referred by Prof. Heer also to cenomanian. Only Ungers' specimen is said to be from neocomian.

In Bohemia these beds contain, besides the plants, only some fresh-water and land animal remains, and are therefore fresh-water deposits; so seem to be also the beds near Moletin and Niederschöna. I am unacquainted with the relations of the English locality, and in Greenland these relations are also not quite clear. Prof. Unger's specimen was associated with marine animals.

The fern stems described from cretaceous rock up to date are as follows:—

1. *Protopteris punctata*, Presl. (Heer, Geinitz, Carruthers, etc.).— From Cenoman in Bohemia, near Vyserovic and Kaunic; Silesia (Giersdorf), in Saxony (Paulsdorf), in England (Shaftesbury in Dorsetshire), and in Greenland (Disco).

1828. *Lepidodendron punctatum*, Sternberg, Versuch einer Fl. d. Vorw. I, 1, p. 19, tab. IV, f. 1, VIII, 2. Described as carboniferous.
1828. *Sigillaria punctata*, Brongniart, Hist. d. végét. foss., p. 421, tab. 141, f. 1. As carboniferous.
1836. *Caulopteris punctata*, Göppert, Syst. filic foss, p. 449, etc. As carboniferous.
1845. *Protopteris Sternbergi*, Corda, Bitrāge, p. 77, tab. 48, f. 1. As carboniferous.
1852. Reus, Jahrb. d. k. k. geol. Reichsanst. Vol. III, N. 2, p. 105. Considered Kounic already as cretaceous.
1853. Krejci, in "Ziva." The locality Kounic is described quite distinctly as cretaceous!
1865 Göppert in N. Jahrb. f Min. etc. Quotes *it* as cretaceous!
1865. *Caulopteris punctata*, Göppert. Zeitsch. d. D. geol. Gesellsch, p. 643, speaks quite distinctly of it as cretaceous!
1865. *Idem* Carruthers, Geol. Magazine, p 484, Pl. XIII, from Upper Greensand!
1869. *Protopteris punctata*, Krejci, in Archiv f. naturh. Durchf. von. Böhmen, I Bd. p, 46, 88—89, described as Cenoman
1870. *Protopt. Strenbergi*, Römer in Geolog. v, Oberschlesien, p. 300, as cretaceous!
1872. *Idem*, Feistmantel Baumfarrenreste, Abhandl. d. k. Böhm. Gesellsch. d. Wissenschaften Distinctly described as cretaceous.
1869. *Protopt. Sternbergi*, Schimp. Pal. veget. I, p. 706. Again as carboniferous.
1874. *Protopt. punctata*, Heer. For. foss. Arctic, Vol. III. Quoted again as carboniferous from Ujaracusuk, Disco, but in the preface correctly referred to Cenoman.
1874. *Protopt. Sternbergi*, Feistmantel, Sitzb. d. k. Bohm. Gesellsch. d. Wissensch. December 1874. As cretaceous, Cenoman!
1875. *Protopt. punctata*, Geinitz. Elbthalgebirge, p. 304. From Cenoman at Paulsdorf in Saxony.

1*a*. *Protopteris Singeri*, Göpp. sp., and *Protopteris Cottai*, Göpp. sp., at first described as peculiar, were later (1865) placed by Prof. Göppert with *Protopteris Sternbergi* Corda.—Both also from cretaceous.

2. *Alsophilina Kouniciana*, Dorm. From Cenoman sandstone near Kaunic (Bohemia).

1853. Krejci-inZiva, Kaunická skála.—Plate.
1872. Feistmantel Baumfarrenreste, l. c.—Figure.

* Sitzungsb. d. k, Böhm, Gesellsch. d. Wissensch. December 1874.

† Mr. Stur's Lepidocaryopsis Westphaleni.

3. *Oncopteris Nettwalli*, Dorm. From Cenoman sandstone, Kaunic (Bohemia).

1853. Krejci, l. c., and 1872 Feistmantel l. c.

4. *Protopteris Buvignieri.*—From cretaceous near Grand Pré (Dpt. Ardennes).

1849. Brongniart Tableaux des genres. d. végét. foss., p. 111.

5. *Caulopteris cyatheoides*, Unger. From Neocomian near Ischl in Austria.

1867. Unger, in Sitzb. d. k. Acad. d. Wissensch. Vol. LV, p. 643—649, Tab. I, f. 1—4.

There are therefore up to date five species of tree ferns from the cretaceous formation all belonging to the same order.

If we now turn to our Indian specimen and compare it with the published figures, we shall find that it mostly agrees with Unger's species from Ischl, although the horizons are somewhat different.

Both these forms agree so much with the living *Cyathea*, that I do not see the necessity for classing them with *Caulopteris*, and I would propose for them the name *Protocyathea* n. g.

### Genus PROTOCYATHEA, Nov.

*Filix arborescens, caule tereti; cicatricibus ramorum (foliorum) spiraliter dispositis, nunc maximis nunc mediocribus, structura earum cicatricibus Cyathearum viventium proxima.*

This genus would comprise two species, that one described by Unger as *Caulopteris cyatheoides* and our Indian form.

### 1. PROTOCYATHEA UNGERI, sp. nov.

1867. Caulopteris cyatheoides, Unger., l. c.
1869. Schimper, Pal. végét., I, p. 708.

Locality: Neocomian near Ischl in Austria.

### 2. PROTOCYATHEA TRICHINOPOLIENSIS, sp. nov., Pl. I, f. 1-2.

*Caule arborescente, vivo tereti, statu fossili compresso, 10 Cm. in diametro metiente, extus cicatricibus ramorum (foliorum) notato; cicatricibus confertis, spiraliter dispositis, oblonge rhombeis, parte inferiore acuminatis, parte superiore obtusiusculis, fossula separatis; disco convexo prominente, subrhomboidali, vasorum stigmatibus circumdato, intus nonnullis vasculis sparsis notato; inferiore parte cicatricis stigmatibus majoribus expleta. Cortice partim tantum preservato.*

The stem is a little compressed and preserved in fine-grained, pretty hard sandstone. It cannot have been very thick, the diameter of the compressed specimen being 10 Cm. The chief character is the scars; they are disposed in spiral order on the outside of the stem, the spirals being pretty vertical. The form of the scars is oblongly rhomboidal, in the lower portion more elongated and acuminated, in the upper portion obtuse; and here pretty convex and prominent (the disk); the scars are pretty closely set and separated by furrows. The discal portion is limited by roundish vascular marks from the other portion of the scar, and the inner surface of the disk contains some other vascular marks. The lower portion of the scars, which is elongated, contains also several larger and more oblong grooves.

To show these grooves in the lower portion of the scars I have added in fig. 2 the view of one scar, which exhibits them very distinctly in form and disposition. They are especially well seen in the scars of the lower portion of the stem, where a little of the stem-substance is preserved.

Regarding the living affinities, we find that our specimen is next related to *Cyathea compta* (see Brongniart, Hist. d. végét. foss., Pl. 42, f. 1), where the discal portion equally is surrounded (limited) by closely set vascular marks as in our fossil form; also in the inner surface of the discal portion seems to be a similar disposition of the marks. The only difference would be that the scars in our specimen are not so distant, and that the marks in the lower portions of the scars are much more numerous in our fossil.

In Hooker's *Species Filicum*, p. 42, I found, however, the *Cyathea compta*, Mart., described as *Alsophila compta*.

Amongst the fossil forms, the next relation of our fossil is with *Protocyathea Ungeri* (*Caulopteris cyatheoides*, Ung.), which is apparently also a *Cyathea*, and Prof. Unger himself has compared it with *Cyathea compta* and *Cyath. vestita*. I have only to refer to his paper (l. c.).

Our species is therefore to be added as a sixth form of tree-fern from cretaceous rocks in the table given above.

*Explanation of Plate.*

Fig. 1. The stem in natural size.
Fig. 2. One scar specially figured to show the stigmata in the lower portion.

## XV.—Notes on the Karharbári Flora.

In two previous papers in the Records (Vol. IX, 3, 4) I had mentioned several fossil plants from Karharbári, which were brought to our knowledge by Mr. Whitty, Superintendent, Karharbári Collieries, East Indian Railway. This year I had an opportunity of visiting the coal-field myself and of collecting fossils, in which I was very much assisted by Mr. Whitty's knowledge of the ground. The flora yielded the interesting fact that it is more related to that of the Talchir shales than is the coal flora in any other field (at least as far as brought to notice at present, except the plants from the Mohpáni coal-field). This relation is also supported by the stratigraphy, both series in this field having the same dip, and being apparently in conformable sequence.

The Talchir flora, as known at present, is very poor, but all species of the real Talchir shale were found again in the Karharbári coal strata. The other character of the flora is, as will be seen, to a great extent triassic, very many forms being like those which European geologists are used to call triassic.

I know at present fossil plants from seven localities in this comparatively small coal-field, and it is to be expected that others will be found.

The localities are—

1. *Buriádi*, yielded ten species and four varieties of one species.
2. *Chunika*, containing one species.
3. *Domaháni*, with five species and two varieties of one.
4. *Passarabhia*, with six species.
5. *Máthádi*, with two species.
9. *Jogitand*, with four species and two varieties.
7. *Komaljore Hill.*

In all these localities the flora shows very much the same character, some species being common to all.

In the Talchir shales themselves I could not succeed in finding any fossils, but I observed very well preserved ripple-marks in the shales.

I shall only shortly give here a sketch of the flora, postponing other details for a future time, when I can give illustrations.

### EQUISETACEAE.

Forms of this class are not so frequent, as in the Damudas, elsewhere.

Some stalks, rather shortly articulated, with small cicatriculæ in the joints and fragments of free leaves, are to be referred to *Schizoneura*, and are next to *Schizoneura Meriani*, Schimp. (*Equiset. Meriani*, Bgt). They are from Passarabhia. From Komaljore Hill *Schizon. Gondwanensis* is known; two similar stalks occurred in the Talchir shales.

*Vertebraria* is very rare; near Passarabhia some small fragments occurred.

### FILICES.

The greatest display of forms is in this class. A large *Neuropteris*, belonging to the triassic single-pinnate type of this genus, occurs very numerously near Buriádi. I have already described it as *Neuropt. valida;* it is very close to *Neuropt. gigantea*, Schimp. and Moug., from the Bunter in the Vosges. The genus *Gangamopteris* is very frequent beside this in all localities; most forms belong to *Gangamopteris cyclopteroides*, which I have previously described, and of which I now could distinguish four varieties. This species was first known from the Talchir shales.

Besides *Gangamopt. cyclopteroides* and its varieties, there are three other species of this genus from Domaháni, Buriádi, and Jogitand. *Glossopteris*, in the true form, is rather rare in the coal-field, and only in two localities more frequent; and I think this species belongs to my *Glossopt. communis*. It is from Passarabhia and Máthádi. From the Talchir shales in the Káranpura coal-field also a specimen of *Glossopteris* is known.

From Buriádi there is known a peculiar form, which shows the transition from *Glossopteris* (real) to *Gangamopteris*, or *vice versâ*. I called it *Glossopt. decipiens*, the midrib of which is quite distinct in the lower two-thirds, vanishes towards the apex, where the secondary veins are radiating.

With the ferns having net-venation *Sagenopteris* is still to be placed.

### CYCADEACEÆ.

*Cycadeaceæ* are pretty frequent amongst the fossil plants from Karharbári coal-field.

*Zamia Hislopi* is very frequent, but longer than the usual form, and I call it therefore var. *prælonga*; in all localities and in Talchir shales. Another very nice *Zamia* shows two leaves attached to the stem; I call it *Zam. Whittiana*, from Buriádi. A *Glossozamites* also occurred near Domaháni. This species I have described shortly in a previous note, and called it after Dr. Stoliczka.

### CONIFERÆ.

Some triassic forms are pretty frequent amongst the plants of this coal-field. They are from Domaháni ghât and Buriádi.

I can determine altogether eighteen species and some varieties. Amongst these are all the plants which are known also in the Talchir shales; besides these there are some triassic types, and some local forms. This, I think, tends to show the close connection of the Karhárbari coal strata with the Talchir shales; and the evidence from the plants speaks strongly for a triassic, or at least mesozoic age of these strata. The bearing of this conclusion upon the age of the Damudas in other fields needs not to be pointed out.

From the vegetable remains in the Talchir shales, which are as well preserved as in the coal-beds, the conclusion would follow that the Talchir shales must have been deposited rather under similar conditions as the coal-bed, and different from those under which the boulder bed was formed.

## XVI.—On the occurrence of Glossopteris in the Panchet Group, and in the Upper Gondwanas.

When reporting in the last number of Records (Vol. X, 2) on some fossils which I collected in the Nunia stream north-west of Assensole, I suggested that some beds above the outcropping coal seam might, from their stratigraphical position, be considered as associated with those which were distinguished as the Panchet group, although *Glossopteris* occurred in them. I added that I had no doubt that this genus passes into the Panchet group. Already in 1861 Mr. Oldham mentioned a *Glossopteris* fragment* from the real Panchet rocks, as described by Mr. Blanford.† Mr. Oldham says:—"There are a few mutilated and drifted fragments of fossils beside, one of which (fragment of one side of a frond) shows the existence of *Glossopteris*, undistinguishable save generically." And the same is repeated again by Mr. Oldham on page 206 in the same paper, so that already at that time there was no mistake about it; but later, it seems to have been generally supposed that no *Glossopteris* exists in the real Panchet group.‡

To satisfy myself how the matter stands, I made a search through all our collections of fossil plants from the Raniganj field in the hope of finding the specimen mentioned by Mr. Oldham. I succeeded in finding about eight leaf fragments, just in those specimens of the rocks which are full of the small *Estheria*, allied to that in the Mángli beds. The *Glossopteris* remains are mostly only fragments of the leaf, but peculiarly well preserved, and one can see the reticulations without the lens, some (about 3), however, show distinctly the midrib, from which the secondary veins pass out, forming distinctly meshes (see figures). Thus there can be no doubt that *Glossopteris* existed during the deposition of the Panchet group. This manner of preservation resembles that in the Kawarsa beds of the Chánda district, where *Glossopteris* occurs also in a very fragmentary state, and again associated with *Estheria* (the form as in the Panchets and in the Mángli beds). In my note on the *Estheria* beds in India §, I have already pointed this out, and I repeat again that the Kawarsa beds very likely are on the horizon of the Panchets in Bengal.

We have thus in the real Panchet group *Schizoneura* and *Glossopteris*, both of which occur again in the underlying Raniganj group; and the Panchet group is certainly as closely connected by fossils with the Raniganj group, as the Mángli beds are with the Kamthi (Raniganj) group. Mr. W. T. Blanford himself found no great unconformity between the Raniganj and Panchet groups. On page 127, l. c., Mr. Blanford says:—"It should, however, be remembered that there is a very considerable apparent conformity between the two groups,

* Additional remarks on the geological relations and probable age of the several systems of rocks in Central India, etc. M. G. S., Vol. III, p. 197, *et seq*.

† On the geological structure and relations of the Raniganj coal-field, M. G. S., Vol. III, pp. 3 and 126.

‡ See a letter by Dr. Oldham to Rev. W. B. Clarke, published in his "Remarks on Sedimentary Rocks of New South Wales," 3rd edition, page 29.

§ Rec. Geol. Surv., X, 1, p. 29

and that excepting in the section on the banks of the Nunia,* the want of it can only be made out by a careful comparison of the rocks of each formation over considerable areas.' And Mr. Oldham, in his paper mentioned above, says about this unconformity:—"The unconformity between them (Raniganj and Panchet groups) is but slight (in truth, such as would never probably have been noticed were the change, from one group to another, not marked by a change in mineral characters of rocks), etc." I went myself twice through this part of the Nunia stream, and I could only observe this apparent conformity, and the co-existence of *Schizoneura* and *Glossopteris* in these beds, and therefore their close connection with the Raniganj group cannot, I think, be denied, whatever may be the differences in mineral characters.

Amongst the fragments of *Glossopteris* which I mentioned above in the specimens of the Panchet rocks, there are easily seen two different forms of areolation: one is that of *Glossopteris indica*, Schimp., and the other of my *Glossopteris communis*. I may thus record the fact that *Glossopteris occurs in two forms in the true Panchet rocks, together with Schizoneura and Estheria*, connecting the Panchet group more closely with the Raniganj group than I supposed before.

But I have also to notice the occurrence of *Glossopteris* in the "upper series" of the Gondwána system,—in the Jabalpur group and in the Denwa groups.

There are some specimens from the Sher river amongst our Jabalpur fossils; one of these I described as *Cyclopteris lobata*, comparing it with the *Cyclopt. digitata* from the English Oolite; but it is also very close to those forms which only recently were described by Heer from Middle Jurassic (oolitic) strata in Greenland and Eastern Siberia as *Gingko*, to which also *Cyclopt. digitata* from Yorkshire was placed, and it would be the case also with our form. On the reverse side of this specimen I discovered the first specimen of *Glossopteris;* by splitting the stone I uncovered another leaf of this genus.

There is another specimen with *Alethopt. Whitbyensis*, Göpp., also from the Sher river, which contains also two leaf fragments of *Glossopteris*. Although fragmentary, the existence of the genus *Glossopteris* in the Jabalpur (Kach) group is unmistakably proved.

In 1875 Mr. H. B. Medlicott brought from the Denwa horizon (Mahadeva Series) of the Satpura basin near Kesla, some specimens of a very crumbling rock with fragmentary plant-remains, amongst which is a leaf, the venation of which is areolated, and which I can only believe to be a *Glossopteris*, with which also the whole form of the leaf agrees. I have no intention to determine the species; I am satisfied with the generical determination. By these discoveries, I think, *Glossopteris* loses somewhat of its "exclusive carboniferous character," which in Australia is given by the marine fauna, while here in India I believe it to be mesozoic.

## ON THE OCCURRENCE OF ERRATICS IN THE POTWAR, AND THE DEDUCTIONS THAT MUST BE DRAWN THEREFROM, *by* W. THEOBALD, *Geological Survey of India.*

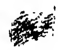
As my assertion of the former extension of glaciers to so low a level as 2,000 feet in the Kángra Valley has found scarcely more favour at the hands of my colleagues than from the author of *Fire and Frost* (*vide* J. A. S. B., 1877, Part II, No. 1., p. 11), it is some satisfaction to me now to produce additional evidence tending to the same conclusion; and if I am not mistaken, less open to the destructive criticism of experts than were my rather crude observations in Kángra.

* The above-mentioned specimens, with *Estheria*, *Schizoneura*, and *Glossopteris*, are from here.

3

1

2



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Indeed, my present evidence goes farther than that of the so-called and so-disputed Kángra erratics and moraines, for in their case I merely argued for a terrestrial or moraine origin which did not exclude the probability of a sufficiently great difference of level in the whole country to largely obviate the isothermal difficulty, whereas I now am forced to contend for floating ice as the vehicle of my Potwár erratics, and this almost precludes the idea of any considerable difference of level between then and now along the Indus basin, the conditions of the problem rather necessiting the supposition of the Potwár then forming a vast lake subsequently drained by the lowering of the Indus bed above Kálabágh.

I will preface my remarks by saying that by the term "erratic," I understand fragments of stone of any size or shape which have been transported by ice, and that the occurrence of blocks of stone (neither meteoric nor presumably due to drift timber), embedded in thinly laminated impalpable silt, is *primâ facie* evidence of ice as the transporting agent.

The Potwár is that vast spread of undulating open ground north of the Salt Range. It is sparingly marked with hills, and rendered somewhat difficult to traverse by deeply excavated streams and ravine-ground, the result of atmospheric denudation acting on a soft alluvial surface. The surface is mainly alluvial, but the underlying Siwalik sandstones often crop out above the surface, or as frequently display themselves in the deep sections afforded by streams and ravines.

The alluvium—or loess, as it has been proposed to be called by some writers—is very variable in character; most generally it is a brown clay, with little or no *kankar* (lime-nodules) in it, and very prone to melt away before rain action; hence the deep intricate ravines which intersect it.

In some spots, as south-east of Fatehjang, towards the Khaire-Múrut range, it presents the character of a lacustrine marl, with thick beds of earthy tufa crowded with land and fresh-water shells, among which I remarked—

*Lymnea rufescens L.* (probably var. of *L. peregra*).
*Planorbis exustus.*
*P. convexiusculus.*
*Vivipara Bengalensis.*
*Bythinia pulchella.*
*Melania tuberculata.*
*Corbicula* (a small species near *Agrensis*).
*Unio* (near *Candaharica.*)
*Macrochlamys Jacquemontii.*
*Cylendrus insularis.*
*Napæus salsicola.*
*Opeas gracilis.*

At other places where less tranquil deposition was taking place, the alluvium has the character of ordinary river deposits, clay, sands, and gravels intermixed; whilst east of Ráwalpindi these gravels are replaced by coarse boulder conglomerates with an aggregate thickness of over 200 feet, and possibly much more, as denudation has largely modified the surface of these beds.

Near Jand a considerable area exists of a fine thin-bedded silt wholly devoid of organic remains, and therein presenting a striking contrast to the equally fine, though dissimilar, clay or marl at Fatehjang. A considerable thickness of this silt is seen (40 feet at least), but its relation to the ordinary alluvium is obscure, it being covered over and masked by enormous quantities of blown sand carried over it from the bed of the Indus by the powerful west winds blowing in the hot season. This silt is impalpably fine and thin-bedded, and of an extremely pale greenish fawn colour, and *in it* are impacted masses of granitoid gneiss, such as constitute the biggest erratic blocks of the district about to be enumerated. One such block, a little under a foot in diameter, was seen in a road-side section north of Jand, impacted *in situ,* and but half exposed by denudation in this silt, the fine laminæ of which were curved against it, as would be in the case of a foreign body embedded in such a position.

This block is not a particularly large one, though its presence in so fine a bed demands a special explanation, but it is valuable as clearly displaying the fact that some, at all events, of the erratics which overspread the surface are weathered *in situ* out of a lacustrine silt indicative at some former period of both lacustrine and glacial conditions in the Potwar.

Near the burial-ground of Jand a deep section of this fine silt is seen, and on it another erratic is seen of about a cubic yard in contents, and this, there seems no reasonable doubt, has also weathered out *in situ,* though it is not so self-evident as in the other case.

It will hardly, I think, be contended that these erratics were transported by floating trees, for this reason, that they are random samples of that spattering of similar blocks many of which are too huge to be capable of any other transport than ice; and this embedded block at all events, from the nature of the materials which surround it, could have been transported by no debacle or even moraine, but must have quietly sunk where it now lies.

The first erratic noticed by me (being first discovered by apprentice Kishen Sing) was in a small stream less than a quarter of a mile west of Pind Sultáni on the road from Ráwalpindi to Jand. At this spot two blocks of a gneissic rock, which probably once formed a single fragment, are seen lying half buried in the sand of a small stream. The larger fragment is nearly ten feet in its greatest length, and nothing approaching this size is seen in the ordinary surface gravel, or in the section of the banks of the stream wherein these blocks lie. Scatttered blocks of a similar gneiss, but of a smaller size, occur at several spots along the road as far as Jand, near which place they are not very uncommon. These fragments are more or less angular, and have nothing in common, so far as appearance goes, with the ordinary rounded boulders and gravel of the Indus, a spill of which materials is found all over the country as we near the Indus, the remnants no doubt of a former high-level deposit of gravel and boulders swept down that river and its tributaries.

About two and a half miles west-north-west of Jand, and a little south of the road to Kushálgarh, occurs a monstrous fragment of gneiss forty feet in girth, and sundry smaller fragments are seen in the neighbourhood, as also a little nearer the Indus; but close to that river these fragments disappear, or are involved undistinguishably in the general mass of boulders swept down in its bed. There is at the spot where this large block occurs much surface gravel, but the rock beneath seems to be the silt I have previously described, which here sheets over and fills in the hollows between the harder Siwalik ridges which here and there crop out above the surface. So obvious is the foreign character of this granitoid rock resting on fine silt, that it has acquired a legendary fame, and is resorted to as a cure for fever, which is effected by the devout pacing it nine times without drawing breath.

The distance between this block and that first noticed at Pind Sultáni is twelve miles, and the direction of the line joining them east-north-east, west-south-west. Along this line small angular erratics are here and there seen, none more than a mile on either side of it; which clearly indicates the linear arrangment of these blocks. To establish this fact I made a traverse to the north as far as Jalwal, besides despatching Kishen Sing in other directions, but without finding any other blocks save those mentioned; whilst to the south I made several traverses equally without result, till the second line of erratics was met, the intermediate ground being free from these fragments. At twenty miles, however, south-east of this line of Jand erratics, a second line of them is met with possessing the same general strike (east-north-east) as the last, and this line I traced for eighteen miles along the course of the Soán river, which must have engulphed many in its sands. This line extends through Shah Mahomedwalla and Jabbi, and some of its fragments are found two miles or a little more on either side of the centre line. The most easterly fragment noticed was a huge mass broken into several pieces, over 20 feet in girth, resting on alluvium at a high level eight and a half miles from Pindigheb and eleven miles from Jaman, and there are several smaller blocks in the same neighbourhood. An equally large block occurs close to Surinli six miles to the south-west, whilst six miles north-west of this last occurs another not quite so large. These two last blocks are the most divergent, being five miles apart, and between them the great central course of blocks seems to pass. Below Shah Mahomedwalla, erratic blocks, mostly of gneiss, are numerous, but above that village the Soán has engulphed them, or the blown sand in the low land south of the river has covered them up. Enough, however, remains clearly to establish the fact of their being two trains of erratic blocks in the Potwár, many of which blocks range from 20 to 40 feet in girth, and some of which at all events are impacted in a thin-bedded silt. These two trains of blocks are twenty miles apart, and their course very nearly at right angles to that of the Indus, but coincident with that of its main feeders in the area in question at the present day (the Soán, etc.).

My colleague, Mr. Wynne, has also found numerous erratics, with an excellent sketch of some of which he has kindly supplied me, but beyond a mere announcement of this corroborative fact I need not now go. The discovery of one or more pieces of the dark Trans-Indus gypsum has, I believe, led my colleague to entertain a suspicion that these erratics have travelled from the west; but this I think must be viewed with the utmost caution, as whether we regard the erratics as borne by floating ice or not, it is hard to concieve that any train of blocks coming from the west would pursue (as I have shown the Potwár erratics to do) a course to the east-north-east.

The above simple exposition of the few facts bearing on this interesting question, gathered by me in the course of my last season's work, must suffice for the present, as till we know more of the direction whence these Potwar erratics descended, speculation on the subject would be vain. One thing, however, I regard as established,—namely, that whilst glaciers were ploughing their way down the great Himalayan rivers and valleys to within 2,000 feet or so of the sea, the Potwár was one great lake, with an exit probably near Kálabágh as now, and into which lake glaciers descended freighted with the debris of the hills of Hazára and Kashmír.

W. THEOBALD.

*Dharmsala, June 1877.*

## ON RECENT COAL EXPLORATIONS IN THE DARJÍLING DISTRICT, *by* F. R. MALLET, F.G.S., *Geological Survey of India.*

AT the time when the construction of the Northern Bengal Railway was commenced, the Government of Bengal, in view of the importance of obtaining, if possible, a supply of coal within a distance less great than that from the known coal-fields of Ràniganj or Kaharbári, requested that an examination should be made into the mineral resources of the Darjíling hills, with reference more especially to coal. To this duty I was deputed during the cold weather of 1873-74. The results of my work are included in Part 1, Vol. XI, of the Memoirs of the Geological Survey.

In that report it was shown that a narrow band of Damuda rocks stretches from Pankabári eastwards as far as Dálingkot, at an average distance of two or three miles from the base of the hills. The strata, however, have undergone great crushing and distortion, and are tilted up on edge, dipping generally at a high inclination: often vertically, and seldom at lower angles than 30° or 40°. Such disturbance is accompanied by great change in the lithological characters of the rocks, the sandstones and shales being frequently converted into quartzites and slates, respectively, while the coal has lost a large proportion of its volatile matter, so as to approach to anthracite in composition. At the same time the crushing to which the seams have been subjected has squeezed them so that they often vary greatly in thickness within a few yards, and has induced a flaky structure in the coal, which renders it so friable that it can be crumbled into powder between the fingers with the greatest ease. With respect to the economic value of the coal, it was pointed out that owing to the high inclination of the seams; their rapid variations in thickness, as well as in dip and strike; the shattered condition of the rocks in many places, and the friable state of the coal, great difficulties were to be anticipated in any attempt to mine the coal; its powdery condition also rendering it useless as fuel until after conversion into either coke or patent fuel.

Considering that the friable condition of the coal was almost beyond doubt due to crushing during the period of elevation of the Damuda rocks, and not to mere atmospheric influences, the opinion was expressed that but little hope of improvement at a distance from the surface could be anticipated. At the same time, the value of workable coal in this part of India would be so immense, even if workable with difficulty, that it was recommended to place this point altogether beyond doubt by driving trial drifts for some distance into one or two of the more favourably placed seams. From these drifts some information would also be gleanable as to the steadiness of the seams with respect to thickness, &c. A seam at Tindhária of 11 feet at the outcrop, and another in the Chirankhola jhora of about 6 feet, were recommended for these experimental openings. Subsequently, however, it was determined to drive into the former of these alone.

The work was placed under the direction of Mr. A. H. Tyndall, Executive Engineer of the Darjíling and Jalpaigori division. In such treacherous ground, with men wholly unaccustomed to work of the kind, the difficulties encountered were by no means small. The hill coolies were most unwilling to work underground with the possibility before them of being buried alive, and two explosions of fire-damp, although they did but little damage, were not calculated to reassure their minds. Neither were they much encouraged by a fall of earth which closed up the mouth of the mine one day just as they were about to enter it for the day's work. Some copper miners from Sikkim, who are accustomed to burrowing in the ground, and who it was supposed would make no difficulty about the matter, were engaged, but on seeing what was wanted, and that the excavation was not in the hard rock they were accustomed to, they declined to have anything to do with it.

The outcrop where the drift was commenced is in the bed of a small stream (about 200 yards south-west of the Tindhária bungalow), from which the ground rises steeply on both sides, the seam crossing the rivulet nearly at right angles, and heading straight into the side of the hill. Work was begun by cutting away the superficial earth and exposing a vertical face at a distance of about 10 feet from the original outcrop. From this point the adit, 4 feet 6 inches high by 2 feet 6 inches broad, was driven, with an upward inclination of about 5 degrees to allow for drainage. Cross-cuts were made at intervals to determine the thickness of the seam. In April last the excavation had been driven to a depth of about 100 feet from the entrance, when the miners were suddenly brought to a standstill by coming on solid sandstone. I was consequently directed to proceed to the place and examine the drift. The accompanying plan* shows its course with reference to the seam, and the cause of the apparent discontinuance of the coal. Owing to a twist of the seam towards the right, the miners got, near the fourth cross-cut, into the dark brown shale, containing some coal, which underlies the main seam, and, penetrating this, came on the sandstone below.

* I am indebted to Mr. Tyndall for the topographical features.

The main object of the drift—the determination of the question whether the coal improves at all in the interior—has however been satisfactorily accomplished, the seam having been followed to a distance of about 80 feet from the original outcrop; and owing to a small land slip which took place last rains, two outcrops have been exposed in an adjacent water-course which yield more information respecting the continuity of the seam than could be hoped for from a further prosecution of the drift. As, therefore, there is no object in carrying the work on any longer, it is advisable to place on record the results obtained.

*Friability of the coal.*—With respect to the friability of the coal, no difference whatever is perceptible between coal taken from the fourth cross-cut and that at the actual outcrop. The former position is about 45 feet from the surface measured along the shortest line; a distance quite sufficient to prove that the friability is, as was anticipated, entirely due to crushing, and not in any degree to surface alteration. No hope can be entertained of obtaining coal from the Darjiling Damudas in anything but the powdery state already described.

*Composition.*—Neither is any difference discernible in the coal as to composition. In the following table assays are given of samples taken at various distances from the surface—

| Distance from original outcrop along drift. | Distance from mouth of drift. | Distance from nearest point of surface. | Fixed carbon. | Volatile matter. | Ash. |
|---|---|---|---|---|---|
| 0 | ... | 0 | 66·3 | 12·4 | 21·3 |
| 10 | 0 | ? | 66·8 | 11·4 | 21·8 |
| 20 | 10 | 7 | 67·5 | 14·4 | 18·1 |
| 30 | 20 | 15 | 64·4 | 10·4 | 25·2 |
| 70 | 60 | 40 | 63·8 | 12·5 | 23·7 |

*Continuity of the seam.*—The section of the seam at the outcrop is as follows (ascending):—

| | Ft. | In. |
|---|---|---|
| (*a*)—Yellowish (slightly rusty) sandstone, seen about ... .. ... | 12 | 0 |
| (*b*, *d*)—Brown shale... ... ... ... ... ... ... | 6 | 0 |
| (*e*)—*Coal* ... ... ... ... ... ... ... | 11 | 0 |
| (*g*)—Sandstone, similar to (*a*), seen ... ... ... ... ... | 8 | 0 |

The shale (*b*, *d*) is only partially exposed, and may include the layer of coal (*c*) visible elsewhere. The dip of the main seam here is west-15°-north at 80°.

In the first cross-cut there is only 5 feet 6 inches of coal, with sandstone on *both* sides of it, the shale (*b*, *d*), and the lower part of the seam, being evidently cut out by a small slip. The dip is badly seen, but appears to be about north-west at 70°.

At the second cross-cut, 6 feet 6 inches of coal is exposed, but the seam has not been cut through on the left side.

In the third cross-cut it is 7 feet 6 inches thick with shale below it. Dip seems to be about west-40,°-north at 80°.

In the fourth, 10 feet of coal is exposed in the main seam, which is not cut through to the right. The dip appears to be the same as in the last cross-cut. There is a thin bed of coal included in the brown shale below.

The fifth cross-cut is entirely in shale, beyond which, at the end of the drift, is the sandstone *(a)*.

About 80 feet south-west of the fourth cross-cut the seam is exposed in a surface outcrop. It has a thickness of not less than 10 feet, and dips about south-20°-east at 30°. I do not think that this is the true dip, however, but merely a bending over of the seam at the outcrop caused by a slip of the surface debris, &c.

Thirty yards further the following section is exposed—

| | Ft. | In. |
|---|---|---|
| (*a*)—Sandstone, seen ... ... ... ... ... ... | 10 | 0 |
| (*b*)—Brown shale ... ... ... ... ... ... | 1 | 0 |
| (*c*)—*Coal* ... ... ... ... ... ... ... | 1 | 0 |
| (*d*)—Brown shale ... ... ... ... ... ... | 3 | 0 |
| (*e*)—*Coal* ... ... ... ... ... ... ... | 12 | 6 |
| (*f*)—Brown shale ... ... ... ... ... ... | 0 | 9 |
| (*g*)—Sandstone, seen ... ... ... ... ... ... | 8 | 0 |

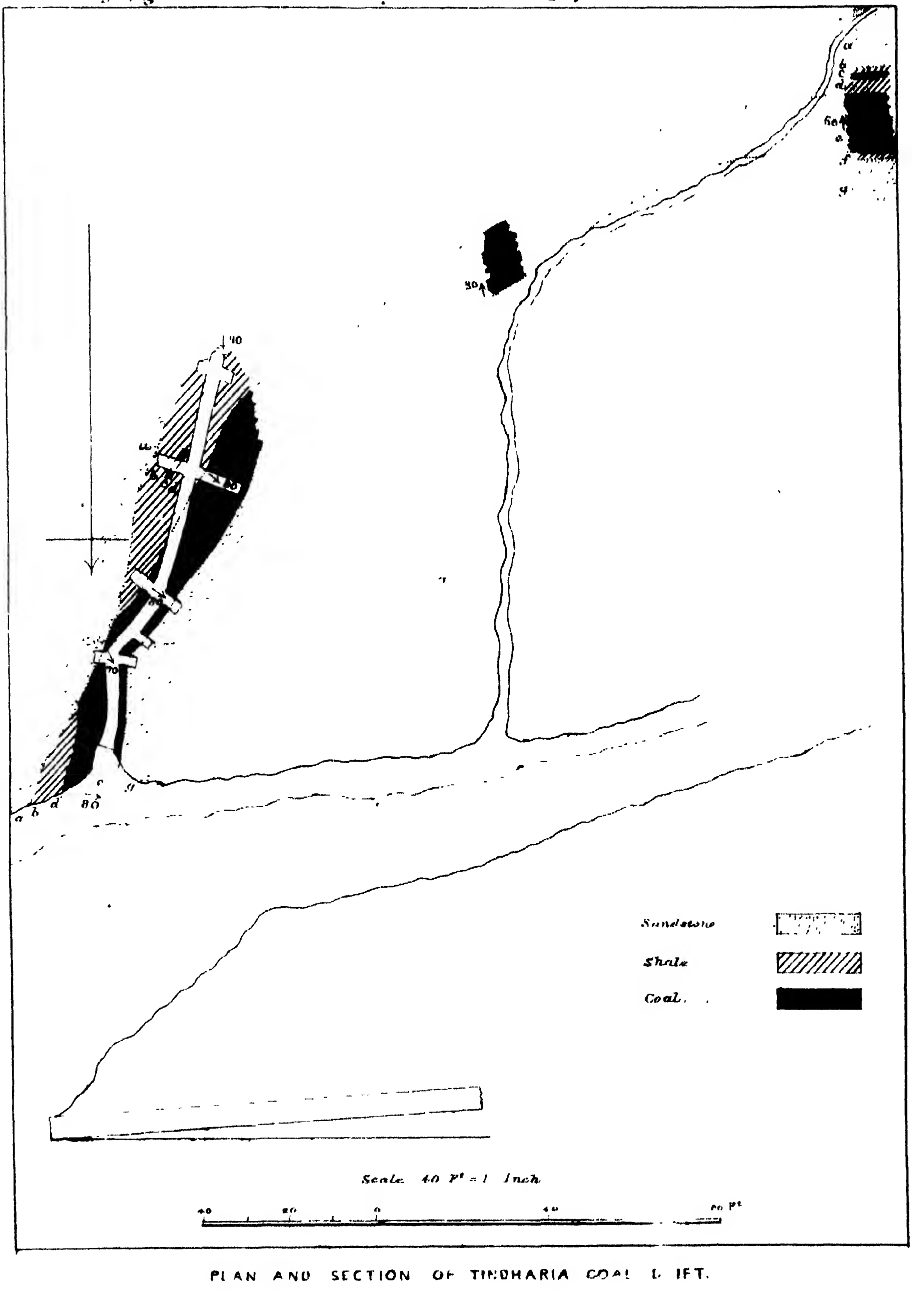
Dip about south at 60.°

Throughout, then, the length of 250 feet in which the seam is traceable, it possesses a fair degree of uniformity in thickness. But the strike twists round from south-15°-west to west, or through 75°; while the dip, which is 80° at one end, is an *inverted* one of 60° at the other, the difference being 40.° Of course these are merely local features affecting one portion of one seam, but my experience of the rocks generally does not lead me to suppose that the beds at Tindhária are subject to any unusual degree of distortion. Taking into account, then, that the Tindhária seam is thicker, and perhaps more uniform in thickness, than any yet found, it is manifest what extreme difficulty the condition of the rocks in question must oppose to any attempt at mining the coal seams generally.

*Necessity for timbering.*—The experience gained shows also that galleries cannot be driven into the coal for a single yard without complete timbering; on which, owing to the incoherent, non-self-supporting character of the coal, an unusually heavy pressure is put (which is shown by 'creep' of the floor of the gallery as well as by bulging in of the sides and roof); and owing to the heat and damp within the drift, the wood quickly becomes unserviceable from rot. With the comparatively trifling superincumbent weight of 40 or 50 feet of rock, some of the 3-inch planks were beginning to yield at the time of my visit; and Mr. Tyndall informed me that it was frequently necessary to renew them here and there, while a complete renewal would be necessary if it were decided to carry the work on further. No doubt the timber would last longer in a regular mine with an organized system of ventilation; but making every allowance for this, it is certain that the expense for timbering in any mines in the Darjíling coal would be extremely heavy.

*Fire-damp.*—It has also been shown that the coal is not altogether free from fire-damp, two slight explosions having occurred during the progress of the drift. There would be little to fear, however, on this score in regular mining operations, as the usual amount of ventilation would doubtless be more than sufficient to carry off the small amount of gas generated.

*Coking properties of coal.*—Some time ago a quantity of the coal was sent by Mr. Tyndall to Calcutta, and through the courtesy of Mr. Blackburn, Manager of the Oriental Gas Company's works, Mr. Medlicott and myself were enabled to experiment on its coking properties, in some gas retorts placed at our disposal.




PLAN AND SECTION OF TINDHARIA COAL LIFT.

About $3\frac{1}{2}$ cwt. of coal in its natural state, *i. e.*, in coarse powder and fragile lumps, was introduced into a retort, which was already at a red heat. The charge was kept at this temperature by means of an external furnace, for five hours, and then drawn. The coal came out in powder just as it went in. It lost its volatile matter, of course, but did not cake in the slightest degree.

Three and a half cwt. of coal, previously saturated with water, was treated in the same way for seventeen hours. The result was the same as in the last experiment.

In a subsequent series of experiments I sought to determine, as far as can be done on a small scale, what proportion of pitch added to the coal was required to give the coke a sufficient degree of firmness. Two pounds of the coal powder, passed through a sieve, of 6 holes to the inch linear, were intimately mixed with different proportions of coal-tar pitch (passed through a sieve of 20 holes to the inch linear), the mixture somewhat shaken down in the crucible, covered over with a thick layer of sand and the crucible lid, and then heated for an hour and a half. When withdrawn, the crucible had been for some time at a full red heat, and the evolution of gas had ceased. The results were as follow:—

| | Proportions. | Quality of coke. |
|---|---|---|
| 1 | Coal 4 parts by weight<br>Pitch 1 " " | Coke hard and firm. |
| 2 | Coal 8 parts by weight<br>Pitch 1 " " | Coke of good quality, but less firm than No. 1. |
| 3 | Coal 12 parts by weight<br>Pitch 1 " " | Coke fairly good; somewhat tender. |
| 4 | Coal 16 parts by weight<br>Pitch 1 " " | Coke inferior; fragile. |
| 5 | Coal 32 parts by weight<br>Pitch 1 " " | Coke very inferior; easily crumbled. |

In a sixth experiment the coal was tightly rammed into the crucible without admixture of pitch. It coked to some extent, being about equal in that respect to No. 5.

It apppears, then, that the Tindhária coal will not coke at all when heated in a loose state, but that it will coke, although in a very inferior way, when previously compressed. It is also to be remarked that the Tindhária coal contains the largest proportion of combustible volatile matter (on the presence of which in sufficient quantity the coking mainly depends) of any Darjíling coal assayed, as shown in the following table.*

| | Fixed carbon. | Volatile matter | Ash. |
|---|---|---|---|
| Rakt naddi, 5′ 6″ seam | 79·3 | 7·6 | 13·1 |
| Cart road, 6′ 0″ seam | 74·1 | 9·0 | 16·9 |
| Chirankhola naddi, 7′ 0″ seam | 69·6 | 5·2 | 25·2 |
| Tindhária ravine, 11′ 0″ seam | 66·3 | 12·4 | 21·3 |
| Ravine south of Pankabári, 0′ 9″ seam | 64·0 | 11·8 | 24·2 |
| AVERAGE | 70·66 | 9·20 | 20·14 |

* Memoirs, G. S. I., Vol. XI, p. 54.

The failure, therefore, to produce good coke in the first experiments leaves little room to hope that such can be produced from any other Darjíling coal.

With respect to the production of coke with the aid of pitch, taking into account, on the one hand, that coke made on the large scale yields better results than in mere crucible experiments, and on the other that the Tindhária coal possesses a slight tendency to cake *per se*, which some other of the Darjíling coals do not, it may perhaps be inferred that about a tenth or twelfth of pitch, or say 2½ *mans* (maunds) to the ton of coal is about the smallest proportion which would be found to answer in practice. The price of coal-tar pitch at the present time in Calcutta being Rs. 2-4 a *man*, this quantity would cost over six rupees at Sukna—that is to say, the pitch alone would cost nearly half the amount at which Ránigauj coal could be delivered there per ton.*

The results of some experiments on a small scale, respecting the manufacture of patent fuel by agglutination with farinaceous matter, are mentioned in my report on Darjíling.† It yet remains to be proved, however, whether this plan would answer on a commercial scale. Attempts of this kind carried out at Ráuiganj, with the object of utilizing the small coal of the collieries there,‡ were successful in the production of good fuel, but not at a paying rate.§

*Conclusion.*—Taking into account the extreme difficulty and corresponding expense which must be encountered in mining the Darjíling coal, and the subsequent expense of converting it into a usable form of fuel, I fear there is but little hope of working it at a rate less than, or even not exceeding, that at which Ráuiganj coal could be laid down at the foot of the hills.

*Assam coal.*—In the coal of Assam, however, there is a supply which may eventually be found more advantageously available than either. If the projected communication should be established between the Názira coal-field and the Brahmaputra, and the branch line of the Northern Bengal Railway to Dubri be constructed, it is not improbable that coal taken down the Brahmaputra would command the market. Coke made from the strongly caking Assam coal mixed in due proportion with the anthacitic coal from Darjíling would probably be found (irrespective of cost) to yield a highly serviceable fuel, but the expense of manufacturing it would most probably be found greater than the cost of delivering the raw Assam coal at the foot of the Darjíling hills.

## LIMESTONES IN THE NEIGHBOURHOOD OF BARÁKAR, *by* F. R. MALLET, F.G.S., *Geological Survey of India.*

NOT long ago, I had an opportunity of examining different deposits of limestone near the western border of the Ránigauj coal-field, which have acquired additional importance of late owing to their employment as flux at the Barákar iron-works. In visiting the different quarries that have been opened, I had, as guide, an intelligent native employe, who was kindly sent with me for the purpose by the Manager of the Company.

The most important localities—in fact the only ones in which limestone has been raised—are two, namely, Bághmára at the western end of Panchét Hill, and Hánsapathar, ten miles

* Memoirs, G. S. I., Vol. XI, p. 62.

† *Ibid*, p. 60.

‡ Records, Vol. VII, p. 162.

§ This fact in itself alone, however, cannot be taken as conclusive against the production of similar fuel in the Darjíling district. At Ránigauj, patent fuel must hold its own against round coal raised on the spot, whereas in the Darjíling district it would have the advantage of competing with round coal brought from long distances.

further west. The limestone in the former locality is of Damuda age, and was originally discovered by my colleague, Mr. Ball, in 1865, and mentioned in his progress report for that year. That at Hánsapathar is included in the gneiss. It was found in 1864-65 by Mr. W. L. Willson during his survey of the crystalline rocks.

*Bághmára limestone.*--Immediately east of the fault which brings the gneiss against the coal-bearing series at Bághmára* there is a north and south ridge composed of Ráníganj sandstone, dipping to the east at an angle of 30 or 40 degrees. It is in the valley to the south of the village, between this ridge and Panchét Hill, that the outcrop where the quarries have been opened is situated. At the time of my visit three quarries had been opened in a line running N. N. E.—S. S. W., the distance between the two furthest apart being some 300 yards. The general section is not as clearly visible as might be wished, but, gleaned from the different exposures of rock, appears to be as follows (descending)—

(*d*).—Sandstone.
(*c*).—Arenaceous limestone.
(*b*).- Shaly red micaceous sandstone.
(*a*).—Limestone.

There is sandstone above the limestone (*c*), but it is not seen in immediate superposition, and there may be other beds between. The upper limestone, as seen in the most southerly quarry, is about 18 feet thick, and is repeated by a small slip. It is very massively bedded, but on the weathered surfaces traces of false bedding can be detected. The dip is east-20°-south at about 20°. The rock is of a dark greyish color and very arenaceous, with scales of mica and occasional bits of carbonized stems, &c.: the fracture is rough and uneven.

The limestone in the second (middle) quarry resembles that in the first. One hundred yards or so to north-west of it there is another outcrop, exposing a few feet of similar rock. Whether this is the same band faulted, or a distinct one lower in the section than (*a*), is not clear, as the intervening ground is covered with surface soil.

A little to one side of the third (most northerly) quarry the arenaceous limestone is partially visible, with a few yards of shaly micaceous sandstone below it resting on the limestone (*a*), which is exposed in the quarry itself. The last-mentioned rock is massively bedded, like the arenaceous band, and similar to it in color, but it is seen by the eye alone to be of a purer kind. The sandy element is much more subordinate, and the fracture is smoother and imperfectly conchoidal. Eleven or twelve feet of limestone is exposed in the quarry, but the bottom has not been reached. Dip east-30°-south at 15°.

I have recently made some analyses of average samples from each band, which give the following results :—

*Upper limestone* (*c*).

| | |
|---|---|
| Calcic carbonate ... ... ... ... | 45·05 |
| Magnesic carbonate ... ... ... ... | 11·53 |
| Ferrous carbonate ... ... ... ... | 3·64 |
| Ferric oxide ... ... ... ... | ·28 |
| Phosphoric acid ... ... ... ... | ·07 |
| Insoluble (chiefly sand, but also includes scales of mica, with some clay and a small quantity of carbonaceous matter) ... | 39·28 |

* *Vide* Map of the Ráníganj Field: Memoirs, Geological Survey of India, Vol. III, Pt. 1.

The residue insoluble in acid contained 84·70 per cent. of silica, equal to 33·27 per cent., or just one-third the total weight, of the limestone.

*Lower limestone (a).*

| | | | | | |
|---|---|---|---|---|---|
| Calcic carbonate | ... | ... | ... | ... | 63·40 |
| Magnesic carbonate | ... | .. | ... | ... | 14·41 |
| Ferrous carbonate | ... | ... | .. | ... | 4·15 |
| Ferric oxide | ... | ... | . | ... | ·62 |
| Phosphoric acid | ... | ... | ... | ... | ·12 |
| Insoluble (sand with clay) | ... | ... | ... | ... | 19·28 |
| | | | | | 101·98 |

Neither limestone contains more than a trace of sulphur. Of the insoluble residue in (*a*), 84·85 per cent., or 16·36 per cent. of the limestone, was silica. It will be seen that the upper band contains double as much insoluble matter as the lower. Exclusive of this, which is mainly mechanically mixed sand, the two limestones have very nearly the same composition.

| | | | | Upper band. | Lower band. |
|---|---|---|---|---|---|
| Calcic carbonate | .. | ... | ... | 74·26 | 78·17 |
| Magnesic carbonate | ... | ... | ... | 19·01 | 17·76 |
| Ferrous carbonate | ... | ... | ... | 6·00 | 5·13 |
| Ferric oxide ... | ... | ... | ... | ·46 | ·77 |
| Phosphoric acid | ... | ... | ... | ·12 | ·15 |
| | | | | 99·85 | 101·98 |

The inferiority of the upper band has been already proved by experience, and the working of it has been abandoned for some time. The only quarry now open is in the lower band, which, as may be seen from the analysis, is of fairly good composition, although containing an undesirably large percentage of silicious matter.

The quantity of lime that may be expected from it is tolerably large. In the present quarry the band has a *minimum* thickness of 11 or 12 feet, and it can probably be advantageously followed for some hundred yards along the outcrop. The average dip of 15° or 20°, however, with rising ground to the east, would not allow of its being quarried far in the direction of the inclination of the beds.

Besides its employment as flux, this stone has been burned for lime to some extent at Narrainpur, where coal is raised, and at Barákar. The distance from the quarry to Barákar is about 10 miles, by a good *kacha* road as far as the Damuda, and over a metalled road for the remainder of the way.

The calcareous horizon may be traced in a north-easterly direction from Bághmára to near the Damuda, west of Narrainpur. But in this northern portion of the outcrop the bands are more earthy and impure than the lower one, at least, at Panchét Hill. There appear to be three or four bands, which are all thin and arenaceous. The sandstone, also, contains calcareous nodules. It would seem as if the deposition of earthy and sandy material has been greater to the north than at Panchét Hill, and that the calcareous element has been more 'diluted' as it were.

A little south of the boundary between the Ironstone Shales and Ráníganj group, at the villages of Jassaidhi and Gangutia (about two miles south-east of Barákar), a band of limestone is visible which seems to belong to the same horizon. It is only a few feet thick, and gave on assay 38·2 per cent. of insoluble matter; so that it is useless as a source of lime.

It appears from the foregoing details that the calcareous bands are in the Ráníganj group, at the lower part of it. The contiguity of the Panchét beds to the limestone, south of Bághmára, is therefore apparently due either to the unconformity between the Ráníganj and Panchét groups,* or to an undetected fault to the east of the limestone.

*Hánsapathar limestone.*—Six miles west of Bághmára there is an abundant supply of limestone of good quality, occurring as a strong band in the gneiss. The country is open, with merely a thin covering of soil, through which the rock penetrates in many places.

In a quarry half a mile west of Hánsapathar the outcrop is some 50 yards broad, the beds having an average dip of 30° to the north, giving a thickness of rock of 70 or 80 feet. Of this, I think, fully three-fourths are available limestone, the remainder consisting of inferior stone, and perhaps intercalated beds of gneiss. The quarry is near the bank of a small stream, and elevated 10 or 15 feet above it; so that there is a large quantity of stone above the water-level. A little to the east, the dip (either by a very sharp twist, or by a fault) alters to east, and is nearly vertical. A short way north of Hánsapathar some 25 feet of limestone is seen in another quarry, but this is only a portion of the whole. On the north side of Asta, again, the rock occurs in great force, dipping to the north at 50°—80°. The breadth of the outcrop is about 60 yards, giving a thickness of, say, 150 feet, of which more than three-fourths is seen to be good stone, free from bands of gneiss, &c. The amount of free drainage here is about the same as in the quarry first mentioned. The limestone is also exposed, although less fully, half a mile east of Asta.

Considering, then, that the outcrop is *visible* for about two miles, and the thickness of the band, it is clear that the amount of stone within reach is very large indeed, while the thinness of the superincumbent soil, and the circumstances of the drainage, allow of its being worked under very favorable circumstances.

The rock is a white crystalline limestone, which varies somewhat in texture. Some parts are comparatively fine-grained; in others the crystalline facets are a tenth of an inch in diameter. Some beds contain strings and nests of quartz and felspar, and disseminated crystals of actinolite. When such impurities occur in large quantity, the beds containing them weather more slowly than the others, and stand out more prominently above the surface. Scales of brown mica (phlogopite?) are frequently scattered through the rock.

The analysis of an average sample of this limestone yielded—

| | |
|---|---|
| Calcic carbonate ... ... ... ... | 83·43 |
| Magnesic carbonate ... ... ... ... | ·78 |
| Ferrous carbonate ... ... ... ... | ·68 |
| Phosphoric acid ... ... ... ... | ·02 |
| Insoluble ... ... ... ... | 16·18 |

Of the insoluble residue, 80·35 per cent. (or 13·00 per cent. of the limestone) is silica. The rock only contains a trace of sulphur (less than ·01 per cent.)

* *Vide* Memoirs, Geological Survey of India, Vol. III, page 126.

The superiority of the Hánsapathar rock to the lower band at Panchét Hill is therefore less marked, with respect to the amount of insoluble impurity it contains, than might be expected from its outward appearance. A large proportion of this impurity consists of white, translucent, silicious grains, which are not easily detected by eye in the similarly coloured stone. But while the Panchét rock contains some 15 per cent. of carbonate of magnesia, the Hánsapathar contains scarcely any, being, with the exception of the insoluble matter, almost pure carbonate of lime. It contains 20 per cent. more carbonate of lime than the Panchét stone, and less phosphoric acid.

Hence, both for use as a flux and as a source of lime, the Hánsapathar rock is markedly superior. But it is also well worth attention as a marble. In texture, colour, and uniformity, it is, I think, equal to the average of the Rájputána marble, which is so well known from its employment in the Táj Mahál at Agra, and other monuments in the North-Western Provinces. Many of the beds are several feet thick—some as much as six or eight; so that blocks of any required size could be extracted.

By the present route, *viá* Bághmára and Narrainpur, the distance from Hánsapathar to Barákar is about fifteen miles, of which eleven is over a *kacha* road, and the remainder over a metalled one. In a straight line, however, it is only twelve, and a direct *kacha* road, easily passable by country carts, could be made at a trifling expense.

Crystalline limestone has also been found at Rámpur and Bhargora by Mr. Ball, and by Mr. Willson at Moháda and east of the village on the bank of the Otla naddi. These places are all a mile or two west of Panchét Hill. In none of them, however, can the rock compare with that of Hánsapathar. The Rámpur stone is the best, but even there the proportion of good stone is comparatively small.

In addition to the two principal localities where limestone occurs, given above by Mr. Mallet, and which were both mentioned by me in an unpublished account of the district of Maubhum, it may be of interest to record the existence of some others in that district. The most important is situated on the main bounding fault of the coal-field, close to the village of Jamuan, about five miles to the south-west of Raniganj and nine miles south-east of Assunsole. There is no specimen of this rock at present available for examination, but when seen, it was noted as being apparently a tolerably pure limestone. As to its abundance, that can only be determined by opening up the ground at the time of its discovery, but a small quantity was visible.

In the other localities the rock is magnesian (dolomitic), and as such unsuited for a flux, but may prove useful for other purposes. One of these localities is situated on the east of the village of Ramlallpur, two miles south of the above given position. The other is on the faulted junction of the crystalline and sub-metamorphic rocks close to the spot where copper ores* occur near one mile north-east of Purda, Pergunnah Manbazaar, and thirty miles east-south-east from Purulia.—*J. Ball.*

## ON SOME FORMS OF BLOWING-MACHINE USED BY THE SMITHS OF UPPER ASSAM, *by* F. R. MALLET, F.G.S., *Geological Survey of India.*

THE smelting of iron, which at one time was an important industry in Upper Assam, more especially along the skirts of the Nágá Hills,† has been extinct for many years. But although the Assamese, in that part of the province at least, have ceased to produce iron themselves from the ore, there is still a not inconsiderable demand for manufactured articles, *dhaus* and spears for barter with the Nágás holding a prominent place amongst such. The materials used now, however, are mainly English iron and steel, which, from their cheapness and the convenient forms in which they are to be had, have driven the native product out of the market.

As the contrivances used by the smiths of Upper Assam are essentially different from those met with in India proper (Peninsular India), the following descriptions may not be

* *Vide* Records, 1870, p. 76.

† Memoirs, Geological Survey of India, Vol. XII, p. 360.

without interest. In India, although the forms of apparatus vary greatly in different parts of the country, they are, I believe, all modifications of the bellows, the supply of air depending on the alternate expansion and contraction of one or a pair of vessels constructed, wholly or in part, of a flexible material, like leather or raw skin. The contrivances used in Upper Assam are blowing cylinders, made of rigid material. Some machines have a double-acting single cylinder; others, a pair of single-acting cylinders. The first of these is the form most commonly used, and may, therefore, be given precedence.

The cylinder (*aa*, plate I), about 3 feet long by 10 inches diameter and three-fourths of an inch thick, is cut out of a solid piece of wood; the excavation of the interior, as well as the shaping of the outside, being done with the ordinary simple tools possessed by the villagers. I have never seen any cylinders which had been turned or bored. Into the ends, disks of wood are fitted by rough dove-tailing (*bb*), the circular joints between disks and cylinder being rendered air-tight with clay. In the centre of one disk is a small hole in which the piston-rod (*c*) works. The latter is generally made from a slip of bamboo split from a large-sized piece, and has a diameter of, perhaps, three-eighths of an inch. At one end is a cross-handle (*d*); at the other, the piston (*e*): this is a disk of wood somewhat smaller in diameter than the cylinder and having a groove cut in the circumference, into which strips of skin from the necks of cocks are sewn by twine passing through holes for the purpose in the edge of the piston. The long, soft feathers fill up the space between the piston and cylinder, and produce but little friction, while not allowing much air to pass through. Rags are also sometimes used for this purpose, but are less effective. In both the end disks there is a double orifice (*f*) fitted with a valve (*g*) opening inwards; the latter made of leather, or a couple of folds of stout paper, fastened at one side by a slip of wood nailed to the disk. The object of the orifice being double is, that the division in the middle may give support to the valve, and prevent it being forced out by the presence of the air when the piston is approaching it.

Close to each end of the cylinder there is a hole (*h*) of an inch or so in diameter, which allows the air to pass into the tubes (*ii*). These are semicircular channels, cut in a piece of wood (*j*) of nearly the same length as the cylinder, to the side of which it is nailed. As the channels approach each other, they bend round and end in circular orifices (*k*), into which are fixed two bamboo blast-pipes (*l*), approaching each other at an angle of about 20 degrees. These reach some way into the tuyere (*m*), which penetrates a clay screen (*n*), the use of which is to protect the blowing-machine from the heat of the charcoal fire (*o*). The cylinder is generally supported on a couple of pieces of wood (*p*), so as to give the blast-pipes sufficient downward inclination. It is securely fixed by a stake (*q*) at each end driven into the ground.

In using the machine, a man sits on the ground, and grasping the handle (*d*), works the piston backwards and forwards with a stroke of about two feet. When pulling, the valve ($g^1$) opens and admits air into the cylinder, while ($g^2$) shuts, so that the entire blast is driven through the pipe ($l^2$). In pushing, the action is, of course, reversed. The two defects of the machine are, that at the end of each stroke there is a momentary cessation of blast, and that a certain proportion of the air drawn into the cylinder is supplied by a return draft through the pipe ($l^1$), which somewhat diminishes the force of the blast into the fire from ($l^2$). The former defect could be remedied by adding an air-chamber, of sufficient capacity to steady the blast, between the pipes (*l*) and the screen, one pipe of larger diameter than (*l*) projecting from the air-chamber into the tuyere. The latter defect could be obviated by closing the holes (*h*) or the pipes (*l*) with valves opening outwards.* In practice, however, neither defect is of much consequence, as the machine, as it stands, answers the

* This defect, and its remedy, has been already pointed out by Mr. Medlicott.—*Memoirs, Geological Survey of India, Vol. IV, p.* 413.

purpose for which it is intended, and gives as strong a blast as is required by the smiths, at the cost of a slight amount of extra labour.

The double-cylinder machine, represented in plate II, was observed at Burhát on the Disáng. Two wooden cylinders (*aa*), about 2 feet 6 inches high and 7 inches external diameter, are placed close to each other, and secured by being tied to two stakes (*bb*) driven into the ground (*cc* represent the fastenings). The upper ends of the cylinders are open, while there is a hole (*d*) about an inch diameter in the side of each, near the bottom. The pistons are similar to that in the last machine, except that there are no handles at top of the rods.

The man who works the machine stands behind it, holding the end of one piston rod in each hand, and working them up and down alternately, one being pushed down, while the other is being pulled up. This machine has the same defects as the first mentioned. As there is only one orifice into each cylinder, the entire indraught would pass through the blast pipe ($e^2$), and greatly diminish the blast into the fire, if the pipes were fixed to the body of the machine. But a space of an inch or so is left between the ends of the pipes and the cylinders. Through it the indraught ($d^2$) mainly takes place, while the force of the direct blast ($d^1$) is not materially diminished.

In the Nágá village of Rangkatu (11 miles south-east of Mákum) I observed an ingenious modification of this blower, constructed entirely out of bamboo. The cylinders (plate III) were each formed out of one segment about five inches diameter, with a portion of a second segment left below the joint, to allow of the whole being firmly planted in the ground. Between the cylinders, which were about a foot apart, an upright was fixed, with a cross-piece tied to it near the top. To this cross-piece the piston rods were fastened, while at the extreme end was a string held by the smith. The piston remote from him being weighted with stones (*aa*), a continuous action was kept up by the smith alternately pulling the string down and allowing it to rise. This machine, although from its smaller size is less powerful than the second one, has an advantage over it in that it can be worked by the smith himself sitting over his fire, without the aid of an assistant.

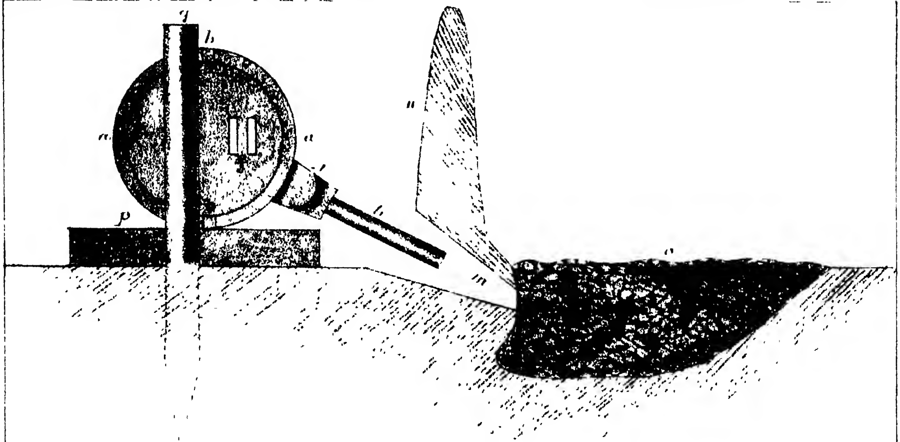
Although, as far as I am aware, blowing cylinders are not used in any part of Peninsular India, they have been found amongst widely-separated communities elsewhere. I am informed by Mr. W. Theobald that a pair of single-acting cylinders, similar to the second machine mentioned above, is commonly used in Mártabán and east of the Sittáng, as well as, probably, in other parts of Burma. The same machine, but of larger dimensions, is also used in Borneo. The cylinder is "made of the stem of a tree hollowed out, about 5 feet 6 inches high and 3 feet in circumference."* The natives on the north coast of New Guinea use a machine made, like that at Rangkatu, out of two large joints of bamboo. "This instrument is identical with the bellows in use amongst the brown races of the Archipelago, from whom it may have been borrowed."† A machine, resembling the Borneo one, is made use of by the natives of Madagascar,‡ who, it appears, may have derived their knowledge of it from Malay sources; and it appears that wooden blowing-machines are common amongst the Chinese,§ from whom, or from the Burmese, it is probable that the Assamese have acquired a knowledge of the principle.

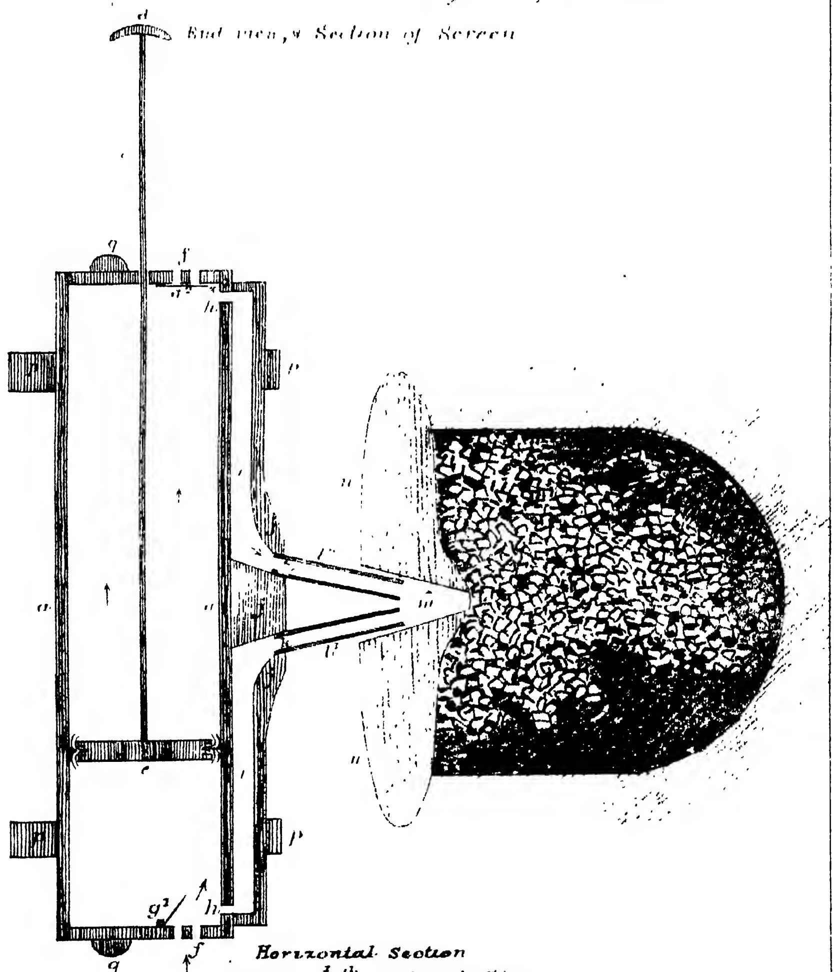
* Percy.—Metallurgy of Iron and Steel, p. 274.

† The native races of the Indian Archipelago, Papuans, by G. W. Earl. M.R.A.S.—Ethnographical Library, Vol. I, p. 76.

‡ Percy.—Metallurgy of Iron and Steel, p. 277.

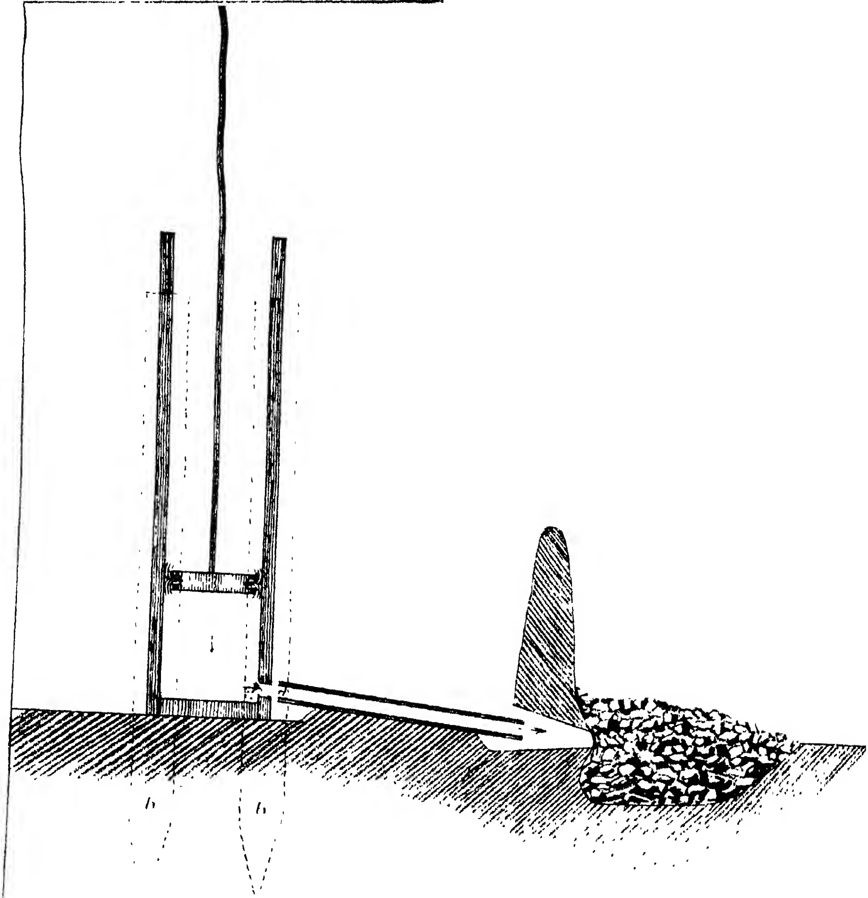
§ *Ibid*, p. 274.






Horizontal Section
Scale $\frac{1}{10}$th natural Size.

Aallet: Blowing machines, Upper Assam

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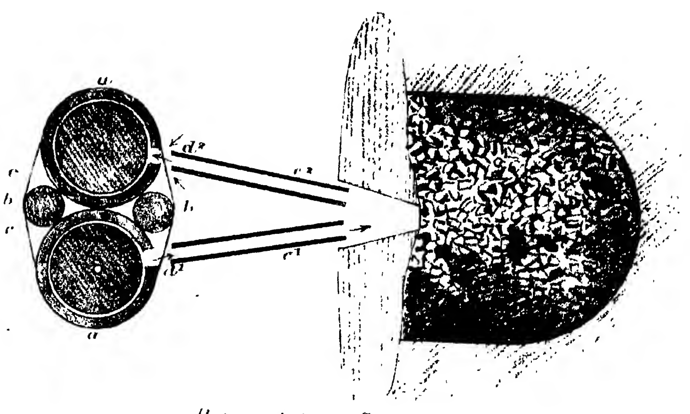


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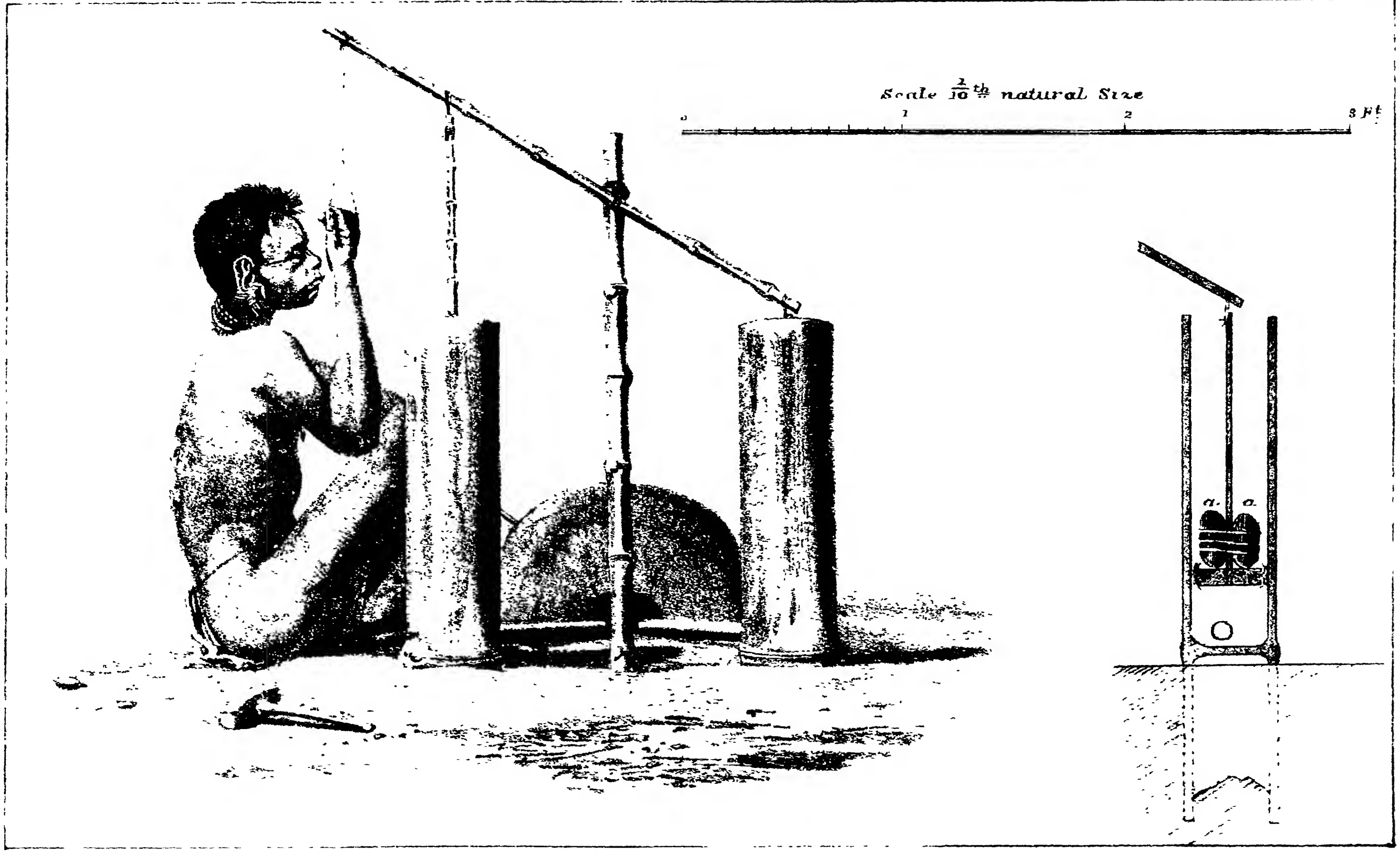
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ANALYSES OF RÁNIGANJ COALS, *by* A. TWEEN, *late of the Geological Survey of India.*

The analyses recorded in the following tables were made in the laboratory of the Geological Survey during the years 1870 to 1873. This detailed examination of Indian coals was undertaken by Dr. Oldham, then Superintendent of the Survey, in conjunction with Colonel Hyde, R. E., then Master of the Mint. A quantity of coal (about four tons) was sent by the leading coal companies from each of their principal pits. A large steam engine was set apart at the Mint, carefully fitted with instruments for recording the conditions of the experiments throughout, for the direct trial of these wholesale samples, each trial extending over several days. Portions of each coal were put aside at intervals during the feeding of the furnace, so as to ensure a fair average; and this was sent to the laboratory for analysis. Thus, as to sampling, which is so important a matter in the case of analyses, when so very small a proportion is actually submitted to examination, it would seem that every precaution was taken to ensure a safe result.

The trials at the Mint were of so tedious a nature, not only in execution but also as involving a mass of complicated calculations, that there was necessarily much delay in preparing the results, and the publication of the analyses was postponed that all might appear together. As these chemical results are, however, quite intelligible by themselves, and have a value quite independent of the other method of trial, it seems a pity not to give them to the public. They are, indeed, much the more accurate and absolute results of the two, being quite free from the many sources of error that beset the grosser method of experiment. The one doubt that affects the analytical method is that of correct sampling, and, as has been said, every care was taken to ensure safety on this score. Some results of the practical experiments have been obligingly placed at our disposal by the Master of the Mint; but unless accompanied by an account of the process of experiment and of calculation, the information would not be complete. For a like reason we do not publish some tests of the same coals kindly furnished by Professor Pedler, who, at Colonel Hyde's request, had measured the evaporating power by Thompson's calorimeter. Only one small fragment (about two or three cubic inches) of each coal was sent for this experiment, so the results could scarcely be taken as representative.

The chemical examination was conducted in the following manner:—Several samples of each coal were sent, corresponding to the number of days of trial at the Mint. These were mixed together and broken up into small fragments, avoiding dust as much as possible. A portion was reserved, from which the analyses were made, and the specific gravity taken. The remainder was burnt in the following manner:—A small portion was first placed upon an open grate and the smokeless flame of a gas burner (over wire-gauze) placed underneath. When this was well kindled, the larger quantity was added, and a chimney placed on top; a very perfect combustion was the result, the ash, before being disturbed, retaining the shape of the fragments of coal, and scarcely a particle falling through the grate.

Two hundred grains of each coal were kept at a temperature of 212° for about four hours for determining moisture; 50 grains were gradually heated in a closed crucible to bright redness for the volatile constituents and coke; 100 grains were burnt in a platinum capsule for estimating the ash. The carbon and hydrogen in the dried coal were estimated by combustion with oxide of copper in oxygen gas, and the sulphur by fusing with nitre, carbonate of soda, and common salt. For the analysis of the ash, 50 grains of the larger quantity burnt were taken. This was fused in two portions with the ordinary fusing mixture. The acid solution of one portion, after removal of silica, was divided for the estimation of the sulphuric acid and phosphoric acid. The remaining constituents were determined from the other portion. A separate portion of each ash was examined for alkali by digestion with water, but no more than a trace was found in any.

| No. of sample. | Name of colliery. | Specific gravity. | Percentage of coke in the undried coal. | Ordinary Assay. Moisture. | Volatile, (combustible). | Carbon, (fixed). | Ash. | Total. | Combustion with Carbon. | Hydrogen. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1 | Bábúsól (B.C.C.) ... | 1·378 | 65·8 | 6·8 | 27·4 | 52·1 | 13·7 | 100 | 68·20 | 5·04 |
| 2 | Maddápúr (B.C.C.) ... | 1·366 | 65·8 | 6·6 | 27·6 | 52·4 | 13·4 | 100 | 68·36 | 4·99 |
| 3 | Mangalpúr (B.C.C.) ... | 1·370 | 67·8 | 5·8 | 26·4 | 55·1 | 12·7 | 100 | 68·91 | 4·80 |
| 4 | Ráníganj (B.C.C.) ... | 1·318 | 64·6 | 6·2 | 29·2 | 49·6 | 15·0 | 100 | 66·46 | 4·89 |
| 5 | Ditto (B.C.C.) ... | 1·360 | 66·0 | 6·7 | 27·3 | 53·9 | 12·1 | 100 | 67·77 | 4·79 |
| 6 | Ditto (B.C.C.) ... | 1·355 | 65·4 | 6·2 | 28·4 | 53·1 | 12·3 | 100 | 66·81 | 4·86 |
| 7 | Nimcha (B.C.C.) ... | 1·422 | 69·0 | 5·4 | 25·6 | 51·1 | 17·9 | 100 | 63·94 | 4·60 |
| 8 | Beldánga (B.C.C.) ... | 1·458 | 66·6 | 5·2 | 28·2 | 48·4 | 18·2 | 100 | 64·28 | 4·48 |
| 9 | Chinákúrí (B.C.C.) ... | 1·370 | 67·4 | 4·5 | 28·1 | 54·4 | 13·0 | 100 | 66·12 | 4·68 |
| 10 | Purriapur (B.C.C.) ... | 1·412 | 70·5 | 3·8 | 25·7 | 51·5 | 19·0 | 100 | 63·07 | 4·60 |
| 11 | Dúmakúnda (B.C.C.) ... | 1·368 | 76·8 | 2·0 | 21·2 | 63·4 | 13·4 | 100 | 71·86 | 4·67 |
| 12 | Sanktoria (B.C.C.) ... | 1·343 | 74·6 | 2·2 | 23·2 | 61·4 | 13·2 | 100 | 68·89 | 4·52 |
| 13 | Mangalpur (N.B.C.) .. | 1·406 | 70·2 | 4·7 | 25·1 | 54·6 | 15·6 | 100 | 66·83 | 4·74 |
| 14 | Dhadka (N.B.C.) .. | 1·414 | 73·8 | 4·0 | 22·3 | 55·7 | 18·0 | 100 | 63·04 | 4·54 |
| 15 | Banali (N.B.C.) ... | 1·369 | 69·4 | 4·2 | 26·4 | 55·3 | 14·1 | 100 | 69·98 | 4·79 |
| 16 | Mangalpur (N.B.C.) .. | 1·389 | 68·6 | 6·4 | 25·0 | 53·4 | 15·2 | 100 | 65·38 | 4·71 |
| 17 | Belrúi (N.B.C.) ... | 1·386 | 71·0 | 3·0 | 26·0 | 55·3 | 15·7 | 100 | 69·12 | 4·96 |
| 18 | Ragunath Bally (N.B.C.) | 1·412 | 73·5 | 3·4 | 23·1 | 54·7 | 18·8 | 100 | 66·03 | 4·50 |
| 19 | Fathépúr (A.) . | 1·462 | 70·0 | 4·2 | 25·8 | 45·3 | 24·7 | 100 | 58·21 | 4·32 |
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| 22 | Charanpúr (A.) ... | 1·375 | 66·6 | 4·8 | 28·6 | 52·0 | 14·6 | 100 | 65·80 | 4·64 |
| 23 | Bénódákatta (?) ... | 1·418 | 80·0 | 1·2 | 18·8 | 62·7 | 17·3 | 100 | 73·39 | 4·01 |
| 24 | Dhasal—Chaukidanga (E.C.C.) ... | 1·352 | 65·4 | 5·9 | 28·7 | 52·8 | 12·6 | 100 | 67·38 | 5·06 |
| 25 | Charakdanga (E.C.C.) ... | 1·385 | 69·0 | 5·4 | 25·6 | 54·5 | 14·5 | 100 | 67·63 | 4·79 |
| 26 | Mangalpúr (R.C.A.) ... | 1·400 | 67·2 | 6·5 | 26·3 | 51·2 | 16·0 | 100 | 64·49 | 4·64 |
| 27 | Púránadip (R.C.A.) ... | 1·501 | 69·2 | 6·5 | 24·3 | 45·5 | 23·7 | 100 | 57·09 | 4·47 |
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| 29 | Topasi (R.C.A.) ... | 1·395 | 67·0 | 6·2 | 26·8 | 51·0 | 16·0 | 100 | 65·38 | 4·72 |
| 30 | Ditto (R.C.A.) ... | 1·407 | 66·0 | 7·0 | 27·0 | 48·4 | 17·6 | 100 | 64·02 | 4·55 |
| 31 | Nigiah (R.C.A.) ... | 1·394 | 65·8 | 5·0 | 29·2 | 48·2 | 17·6 | 100 | 63·77 | 4·62 |
| | Averages ... | 1·393 | 69·0 | 4·8 | 25·83 | 53·2 | 16·17 | 100 | 66·2 | 4·64 |

B. C. C.—Bengal Coal Company.
N. B. C.—New Birbhúm Company.
A.—Messrs. Apcar and Co.

| Oxide of Copper in Oxygen. | | | | Composition of the Ash. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oxygen and Nitrogen. | Sulphur. | Ash. | Total. | Silica. | Alumina. | Oxide of Iron. | Lime. | Magnesia. | Sulphuric Acid. | Phosphoric Acid. | Total. | No. of sample. |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 10·66 | 1·10 | 15·0 | 100 | 60·40 | 23·67 | 8·25 | 2·47 | 3·37 | ·35 | 1·31 | 99·82 | 1 |
| 11·33 | ·82 | 14·5 | 100 | 52·92 | 33·48 | 6·60 | 2·30 | 1·27 | 1·20 | ·66 | 98·43 | 2 |
| 12·11 | ·88 | 13·3 | 100 | 59·66 | 26·72 | 8·08 | 2·92 | ... | 1·00 | 1·18 | 99·56 | 3 |
| 11·35 | 1·30 | 16·0 | 100 | 60·24 | 28·30 | 7·04 | 1·80 | ·42 | 1·00 | ·78 | 99·58 | 4 |
| 13·58 | ·86 | 13 0 | 100 | 57·00 | 25·46 | 9·60 | 3·28 | ·94 | 1·30 | 1·03 | 98·61 | 5 |
| 14·27 | ·96 | 13·1 | 100 | 58·04 | 26·47 | 9·17 | 3·38 | ·30 | ·80 | 1·50 | 99·66 | 6 |
| 11·56 | 1·00 | 18·9 | 100 | 57·50 | 25·52 | 11·20 | 3·67 | ·51 | ·50 | 2·00 | 100·90 | 7 |
| 11·18 | ·86 | 19·2 | 100 | 46·04 | 16·20 | 31·06 | 3·96 | 1·40 | ·50 | 1·77 | 100 93 | 8 |
| 13·97 | 1·23 | 14·0 | 100 | 62·68 | 22·88 | 8·32 | 1·82 | 1·12 | ·85 | ·71 | 98·41 | 9 |
| 11·88 | ·75 | 19·7 | 100 | 62·50 | 24·32 | 9·64 | 2·13 | 1·21 | ... | ·33 | 100·13 | 10 |
| 8·78 | ·69 | 14·0 | 100 | 60·54 | 31·00 | 6·52 | 1·21 | ·94 | ·55 | ·51 | 101·30 | 11 |
| 12·27 | ·82 | 13·5 | 100 | 58·00 | 29·03 | 7·49 | 3·26 | ... | 1·11 | 1·46 | 100·35 | 12 |
| 11·15 | ·98 | 16·3 | 100 | 57·20 | 33·82 | 4·00 | 3·48 | ... | ·50 | 1·10 | 100·11 | 13 |
| 13·02 | ·40 | 19·0 | 100 | 64·02 | 29·22 | 3·62 | 1·54 | ·81 | ·55 | ... | 99·76 | 14 |
| 10·06 | ·37 | 14·8 | 100 | 62·77 | 30·48 | 3·32 | 3·18 | ... | ·47 | 1·20 | 101·42 | 15 |
| 12·66 | ·55 | 16·7 | 100 | 57·52 | 32·04 | 4·47 | 4·63 | . | ·45 | 1·65 | 100·76 | 16 |
| 9·15 | ·57 | 16·2 | 100 | 62·66 | 29·21 | 3·80 | 2·55 | ·75 | ·48 | 1·41 | 100·86 | 17 |
| 9·38 | ·69 | 19·4 | 100 | 64·89 | 27·71 | 2·55 | 3 10 | ... | ·40 | 1·65 | 100·30 | 18 |
| 11·13 | ·54 | 25·8 | 100 | 63·75 | 28·73 | 4·83 | 1·96 | ... | ... | ·64 | 99·91 | 19 |
| 10·58 | ·82 | 17·4 | 100 | 62·85 | 30·56 | 3·28 | 2·00 | ·55 | ·45 | ·75 | 100·44 | 20 |
| 5·49 | 1·20 | 23·2 | 100 | 73·00 | 26·26 | . . | ·80 | ... | ... | ... | 100·06 | 21 |
| 13·15 | 1·01 | 15·4 | 100 | 57·16 | 34·51 | 2·62 | 4·15 | ... | ·50 | 1·10 | 100·34 | 22 |
| 4·35 | ·95 | 17·3 | 100 | 64·05 | 25·86 | 9·18 | 1·31 | ... | ... | ... | 100·40 | 23 |
| 13·10 | ·96 | 13·5 | 100 | 61·75 | 32·70 | 2·90 | 2·51 | ... | ... | ·84 | 100·70 | 24 |
| 11·39 | ·79 | 15·4 | 100 | 58·00 | 32·54 | 4·00 | 4·21 | ... | ... | 1·46 | 100·21 | 25 |
| 12·97 | ·80 | 17·1 | 100 | 58·16 | 34·45 | 5·55 | 2·55 | ... | ... | ·40 | 101·11 | 26 |
| 12·51 | 1·63 | 24·3 | 100 | 63·16 | 26·46 | 6·16 | 2·88 | ... | ·25 | 1·03 | 99·94 | 27 |
| 11·03 | ·74 | 16·3 | 100 | 64·14 | 30·37 | 2·11 | 2·94 | ... | ... | ·95 | 100·51 | 28 |
| 12·05 | ·85 | 17·0 | 100 | 62·00 | 28·11 | 4·41 | 3·07 | ... | ... | 1·02 | 99·51 | 29 |
| 11·77 | ·86 | 18·8 | 100 | 65·19 | 27·80 | 4·10 | 2·40 | ... | ... | ·20 | 99·69 | 30 |
| 12·61 | ·50 | 18·5 | 100 | 64·10 | 29·33 | 2·28 | 3·40 | ... | ·53 | 1·00 | 100·64 | 31 |
| 11·30 | ·85 | 17·01 | 100 | 60·70 | 28·51 | 6·32 | 2·77 | ·43 | ·44 | ·83 | 100·00 | |

E. C. C.—Equitable Coal Company.
R. C. A.—Ráníganj Coal Association.

NOTE.—The 31 samples of coal furnished by the five great coal proprietors in the Ráníganj coal-field, namely, the Bengal Coal Company, the Ráníganj Coal Association, the Equitable Coal Company, the New Birbhúm Coal Company, and Messrs. Apcar and Co., represent fairly the quality of fuel which can be supplied from our oldest and most extensively worked coal-field.

The large quantity of ash is the feature that characterises our Indian coals, and to this circumstance is due their diminished vitality as contrasted with English coals. The proportion of oxygen, too, is a disadvantage, reducing the calorific power of the fuel; but I do not perceive that, as compared with the average of British coals, those of the Raniganj field show unfavourably. As regards sulphur, the Indian coals are on the whole more free from it than the English, the mean of—

| | | |
|---|---|---|
| 37 Welsh samples being ... ... ... ... ... | 1·42 | Playfair and De la Beche's investigations. |
| 8 Derbyshire „ „ ... .. . ... ... | 1·01 | |
| 28 Lancashire „ „ ... ... . .. ... | 1·42 | |
| 17 Newcastle „ „ . ... ... ... ... | ·94 | |
| 8 Scotch „ „ . ... ... ... ... | 1·45 | |

The excessive amount of ash is the chief defect of the coals raised in the Ráníganj field, and I think it vain to expect that any deeper workings will effect any improvement in this respect.

A point of some interest, but which, unfortunately, the foregoing analyses bear upon but slightly, is the relative values of the coals from the upper and the lower measures. Out of all the samples there are only two from the lower measures—No. 11, Dúmákúnda pit coal, owned by the Bengal Coal Company, and No. 23, Benodákatta quarry coal, belonging to Messrs. Apcar and Co. The accident of distribution has rendered the beds of the upper measures most accessible, and it is amongst them that the greatest number of collieries have been opened out; hence there is a large preponderance of samples of the upper coals. The Dumákúndá and Benodákatta coals both appear to be of high heating power, and their theoretical fuel-value expressed in heat-units is as compared with carbon as follows:—

| | |
|---|---|
| Carbon ... ... ... ... ... ... | 8080° (Centigrade.) |
| Dúmákúnda ... ... ... ... ... ... | 7040° |
| Bénódákatta ... ... .. ... ... | 7023° |

In none of the coals of the upper measures does the calorific power when theoretically calculated exceed that of these two samples; and though the above figures may not be accepted as the true gauge of the practical working value of these coals, I think they tend to show that the beds of the lower measures are worthy of attention. The ultimate analysis of these two coals indicates a higher percentage of carbon than in any others, and a less amount under the head of oxygen and nitrogen, both of which are important circumstances in their favour.

I have heard practical men express very conflicting opinions about both of these coals: each one was, probably, speaking according to his conviction; but with the evidence of the analyses before me, I am inclined to ask whether those who condemned the coals saw them fired under suitable conditions.

Of gas-coals, the best known is Sánktoria, which yields about 9,000 cubic feet per ton; the seam varies in quality along its strike, at Belrui there being a less percentage of permanent gases in the volatile matter than at Sánktoria. The analyses of these two samples from the same seam show for Sánktoria coal 25·4 per cent. of total volatile matter, and for Belrui 29 per cent, yet Sánktoria coal yields more cubic feet of gas per ton. I draw attention to this circumstance in order to illustrate the fact that comparisons between the total amounts of volatile matter are no guide to the relative gas-producing merits of coals.

T. W. H. HUGHES.

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H. READ, Esq.,
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(*through* V. BALL, Esq.)

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# RECORDS

OF THE

# GEOLOGICAL SURVEY OF INDIA.

**Part 4.]** **1877.** **[November.**


ON THE GEOLOGY OF THE MAHANADI BASIN AND ITS VICINITY, BY V. BALL, M.A., F.G.S., *Geological Survey of India.*

A detailed description of the geology of the extensive area included in the accompanying map, even to the limited extent to which the details of a large portion of it are known, would occupy a very much greater space than is available for the purpose in these pages. In the appendix below will be found a list of papers which describe the coal-fields and certain other parts of the area which have been made the objects of special examination. This account is intended mainly to afford a general sketch of the geological features of those portions of the area of which hitherto there has been no published description whatever. The *data* available for this purpose are derived *firstly*, from manuscript accounts of traverses of the Chhattisgarh basin made by Mr. Medlicott in 1866-67 and by Mr. W. T. Blanford in 1869-70; *secondly*, from my own observations made during the past and previous seasons.

The geographical tract which is coloured geologically on the map embraces an area of about 50,000 square miles, in which the following British Districts and Native States are situated: Cuttack, with portions of the Garjat states of Orissa; Gangpur, and Udaipur and other minor states of the Chutia Nagpur Division; Sambalpur, with portions of its Garjat states of Sonpur, Patna, Borosambar, Phuljhar, Raigarh, and Kalahandi; the Jaipur State under Vizagapatam; the Bustar State under Sironcha; Karial or Kariar, Bindra-Nowagarh, and various other states of the Raipur District. In other words, the area includes portions of the south-west frontier of Bengal, nearly the whole of Orissa, a small portion of the northern frontier of Madras, and a considerable portion of the most eastern districts of the Central Provinces.

PHYSICAL FEATURES.—On a map of so small a scale as that which accompanies this report, it would be impossible to effectively delineate the various groups of hills and plateaux, marked and extensive as some of them are. It has therefore been thought better to omit altogether the inadequate hill shading of the original map from which this edition has been produced, thereby securing greater clearness for the names and geological boundaries. But it will be well for the reader to bear in mind that throughout about two-thirds of the whole area broken hilly ground prevails. The first great group of hills to be mentioned forms a section of the Eastern Ghâts stretching in breadth from the neighbourhood of Berhampur, the Chilka Lake, and Cuttack, for a distance of about 130 miles westward to the valley of the Tel River in Kalahandi. North of the Mahanadi, this broad zone continues through Keonjar and Moharbanj, losing itself on the east in the plains of Midnapur and Singhbhum, but maintaining its western branch strongly through Lohardugga and Hazaribagh.

In the Khond Malias, as the zone south of the Mahanadi is called, the peaks are commonly from 2,000 to 3,000 feet high, a few rise to 4,000 feet, and there are some known to exceed 5,000 feet in elevation.

In the neighbourhood of Sambalpur and southwards, in Patna and the western portion of Kalahandi, there is a good deal of tolerably level ground, but here and there isolated peaks and ridges rise from it. To the west of Sambalpur an extensive group of hills is situated on the south bank of the Mahanadi, spreading thence into Phuljhar and Borosambar. To the north-west of Sambalpur is the hilly country of Raigarh and Hingir, which is continued towards Korba and Udaipur. Still further west is the Mandla plateau. In the Raipur states of Karial and Nowagarh, to the south-west of Sambalpur, the country is excessively hilly. First we have, centrically situated as regards the two states, an extensive plateau averaging about 2,500 feet in elevation, and on either side of this plateau, there are numerous ranges and groups of hills, the latter being of more or less foliated metamorphic rocks, while the plateau is formed of horizontal beds of quartzite. To the south of this rises the Jaipur-Bustar plateau, which averages about 1,800 feet in elevation. On the east and south it is bounded by still higher ridges, spurs from the Eastern Ghâts; on the west and also below the southern bounding ridges, it falls by rapid steps to the Godavari valley; on the north-west it slopes off gently towards Raipur, but on the north-east it is bounded by steep scarps, the ghâts through which lead down into the valley of the Tel River, some 1,000 feet below.

The watershed between the rain-basins of the Mahanadi and Godavari traverses the northern portion of this plateau from west to east, and then runs to north-east through the Kalahandi portion of the Eastern Ghâts.

RIVERS.—The principal rivers of our area are the Mahanadi, with its tributaries the Tel, Ebe, Kelu, Mand, and Hasdu, besides many other minor streams too numerous to be mentioned here. The total length of the Mahanadi from its sources in the north-western corner of Jaipur and the neighbouring district of Bustar to the sea is about 500 miles. Of rivers belonging to other basins, but portions of whose courses are included in the accompanying map, the Brahmini on the north-east, the Weingunga on the west, and the Indravati on the south are the principal. The first mentioned is the principal river of its own system, while the two latter are tributaries of the Godavari.

GENERAL GEOLOGY.—So far as is at present known, no series of rocks other than those included in the following list occurs within the limits of this area:—

Alluvium.
Laterite.
Deccan trap and Lameta beds.
Rajmehal series—
  Atgarh group.
? Mahadeva series.
Damuda series—
  Kamthi (Raniganj) group.
  Barakar group.
  Talchir group.
Vindhyan (Karnul) series—
  A. Karial quartzites and sandstones.
  B. Raipur limestones, shales and sandstones.
[Sakoli beds.]
Metamorphic series.

## ALLUVIUM.

Under this heading there is little to be said at present. In the published accounts of the coastal districts there will be found some remarks on the subject. In the higher parts of the Mahanadi valley up to the Raipur district, so far as they are known, there are no deposits of alluvium of sufficient extent to constitute alluvial plains as the term is ordinarily understood. Patches of true alluvium of limited extent do occur in the vicinity of the river, and in the Raipur district, which I have not examined; there may possibly be deposits meriting special notice, but in the rocky districts of Sambalpur and Orissa, the alluvium is much mixed with local rock-debris and laterite. In the valley of the Tel, where it traverses Patna and Kalahandi, there is a kunkur-bearing alluvium, sometimes of wide extent, and which attains an importance from the fact of its concealing the rocks. On the Jaipur-Bustar plateau, in the river valleys between the laterite, the alluvium is sometimes of considerable thickness, if not of wide extent. Thus the Indravati sometimes affords sections of 20 feet of a reddish sandy alluvium with no rock appearing beneath.

## LATERITE.

Regarding the coastal laterite I only add, to what has already been published on the subject, that in the cuttings through some ridges of laterite on the Khurda road I recently found numerous lenticular masses of dense shaly iron ores which seemed to explain the source from whence considerable accumulations of fragments of similar shale, which I had previously met with, but had hesitated to identify with laterite, had been derived.

The occurrence of laterite in the vicinity and on the rocks of the Raigarh and Hingir coal-field has already been described by me. At that time I had met with no example of high-level laterite in Sambalpur, but during the past season I found several remarkable deposits at high elevations both in that district and others further south. These all occurring in a country into which there is no evidence of the Deccan trap ever having extended seem to be worthy of special description and notice.

The Gandamardan range on the borders of Patna and Borosambar which rises 2,000 feet above the general level of the country, both from its altitude and its flat plateau top, presents a striking appearance when seen from a few miles distance. At first it seemed probable that the structure might be due to flat-capping beds of Vindhyan quartzite, but on examination it was found that the range consisted of steeply inclined garnetiferous and ferruginous gneiss, with a cap of about 100 feet of laterite. The summit is a flat plain with sparse vegetation very similar in many respects to the Main-pât in Sirguja.

On the Karial-Nowagarh plateau which, as is above stated, averages 2,500 feet in elevation, I found some scattered thin patches of laterite, possibly the remnants of a once continuous bed of which, in parts unvisited by me, there may still, perhaps, be better preserved examples. The massive Chaoria hill on the borders of Karial and Kalahandi is not improbably capped with laterite, judging from its flattened appearance as seen from a distance.

In the south-eastern parts of Kalahandi there are a number of *pâts* from 3,000 to 4,000 feet high; of these I was only able to ascend one, Baplaimali, seven miles east of Moulpatna. Its elevation above the sea, according to the Altas Sheet, is 3,587 feet, of which the upper 300 feet is formed of a bed of laterite resting on the up-turned edges of metamorphics. From Baplaimali a good view of a number of other *pâts* is obtained (particularly of Sijimali 4,058 feet). All owe their plateau form to similar laterite caps, which in all probability formed, at one time, a continuous bed throughout a wide area.

In the Jaipur-Bustar plateau, which has an average elevation of about 1,800 feet, laterite, though perhaps of inconsiderable thickness, is very widespread, often completely concealing the underlying rocks over many square miles. In the vicinity of Kotepad and for many miles both to the north and south of it the laterite is especially conspicuous forming numerous low hills, to the terraced alluvial valleys between which the cultivation is restricted.

Raised above the main Jaipur-Bustar region are several minor plateaus; the first of these to be mentioned is one formed of quartzites resting on a metamorphic base and which has an average elevation of about 2,500 feet, like the Karial-Nowagarh plateau. Its position is on the corner of the plateau south of Deobogh. Resting on the quartzites I found, as in the former case, traces of a once continuous bed of laterite. In the Poragar hills again we have a range which rises about 1,200 feet above the main plateau or to a total elevation of about 3,000 feet. The thickness of the laterite cap in this case varies with the irregularity of the underlying surface between from 50 to 100 feet. It would seem then that in this area on all elevations of 2,500 feet and upwards there are traces of laterite, which, it is possible, originally formed portions of a once continuous bed. This may have followed, however, a configuration of the country not very different from that existing at present.*

Many of these laterite caps prove to be most efficient store-houses for water and are consequently not unfrequently the sources of perennial springs; of this the Gandamardan range affords numerous examples.

### DECCAN TRAP AND LAMETA BEDS.

In the scarp of the Mandla plateau representatives of the above groups have been observed overlying the Vindhyan rocks of the Chhattísgarh basin. These have not been subjected as yet to detailed examination, and cannot therefore be described in the present account.

### RAJMEHAL SERIES.

The sandstones of the Atgarh basin and the fossil plants which have served to determine their position as belonging to the above series have recently been described in these pages†; so far as is certainly known, there is no other deposit of rocks of the same age within our area; but it may be well to record here that I noticed a strong lithological resemblance between certain conglomerates of the Atgarh basin and the highest beds in the Talchir field. The post-Barakar rocks of that area, however, have not yet been thoroughly discriminated.

When at Khurda I was informed, on apparently reliable authority, that sandstones occur some forty miles to the south-west. If such is really the case, they will not improbably prove to be of the same age as the Atgarh rocks.

### ? MAHADEVA SERIES.

Overlying the rocks of the Barakar group, in the Talchir field, there is a considerable thickness of clays, sandstones, and conglomerates; these, although partially represented by some small outlying patches in the eastern half of the field, are only fully developed in the wild, thinly inhabited, and hilly region of the west, of which no accurate map was available at the time of my visit in 1875. In the original Talchir report these rocks were referred to the then recognised Mahadeva series, and were credited with an estimated thickness of from 1,500 to 2,000 feet; their unconformity with the underlying Barakars was fully

* Near Jashpur, in Chutia Nagpur, there is such a bed which encrusts hills and valleys alike, the effect to round off angularities, not to fill up valleys to the level of the hill tops.

† Records, 1877, Vol. x, pt. 2, p. 63.

established by the remarkable section at Patrapara, where the lowest bed is seen resting on the denuded edges of a coal seam and some other cases of a more general character. In further confirmation of this view, I met with several cases, more particularly at Tipapani near Landimal on the extreme west of the field, where a coal seam with associated sandstones is unconformably overlaid by a pebbly grit of the upper series.

Overlap unconformity exists on a large scale in the west. Except at Tipapani the rocks underlying these beds are either Talchirs or metamorphics, the edges of the Barakar beds being wholly concealed.

That these rocks belong to two or perhaps even more groups is probable; indeed, in the section of the Ouli River to the south of Patrapara, I thought I could detect some indications of unconformity. We there find a thickness of not less than 600 feet, possibly much more, of yellow and white sandstones with purple clays; these rocks seemed to be much more disturbed than the conglomerates which cap the neighbouring hills.

The conglomerates, of which there is here a thickness of 800 feet, are all more or less ferruginous, and contain quartz pebbles with jaspery ironstone and in some cases nests of white clay. It is possible that these may belong to a distinct group, and their lithological characters suggest a connection with some of the local groups of the upper Gondwana system, more especially with those formerly included in the Mahadeva series.

The above-mentioned yellow sandstones and purple clays are seen in several other parts of the area, more especially two miles east of Kondaikula, where they occur faulted against the Talchirs and are overlaid by ferruginous sandstones. In some respects they resemble Panchet beds of the typical Raniganj area, corresponding thus with some beds of the Kamthi group in the Chanda country. At Intosoro, on a horizon slightly higher than that occupied by these beds, there are sandstones and conglomerates and red clays which seemed to me to be precisely identical with rocks seen in the adjoining field near Hingir. On the whole, in the absence of fossils, it is only possible to form a conjecture as to the affinities of these upper rocks, but the balance of evidence seems to favor the view that, while at least a portion of them may not improbably belong to the same age, *i. e.*, Kamthi, as the rocks of the Hingir group in the adjoining field, the remainder may represent a group of the upper Gondwanas. I have already noted a certain resemblance to exist between the highest conglomerates and some of the Atgarh rocks; this, however, may only be accidental.

### DAMUDA SERIES.

*Kamthi Group.*—In the published account of the Raigarh and Hingir field, a list was given of the fossils obtained in the rocks which were temporarily distinguished as the Hingir group. This list, corrected after further examination by Dr. Feistmantel, includes the following species, which are considered to be quite sufficiently numerous and characteristic to admit of the correlation of the Hingir and Kamthi groups,—thus confirming the conclusion which seemed probable from the lithological and stratigraphical characters:

EQUISETACEÆ.

*Schizoneura Gondwanensis* (leaves and stalks).
*Vertebraria indica*, Royle.

FILICES.

*Sphenopteris polymorpha.*
*Pecopteris* sp.
*Glossopteris indica*, Schimp.
*Gl. Browniana* (?) Bgt.
*Gl. angustifolia*, Bgt. (with marginal line).
*Gl. communis*—and another species.

The title Kamthi is in this case preferable to Raniganj, as the lithological character of the rocks is much more closely allied to those of the former than of the latter group. It is unnecessary to add here anything to what has already been stated above as to the occurrence of representatives of this group in the Talchir field.

*Barakar Group.*—In the accounts of the Talchir, Raigarh-Hingir, and Korba fields will be found nearly all that has been ascertained with regard to the occurrence of rocks belonging to this group. That the Hingir field is connected with that of Korba is known to be the case, but the intervening country has not yet been examined in detail. In view of the possible importance of this field at no very distant period it may perhaps be of service to state that in the area temporarily distinguished as the Udaipur coal-field, the Mand River, and its tributaries the Korja, Samasota, Meria-Kota, Ududha, Saria, Sirni, Kopa, Kharandhoa, Pori, and Baghond, all exhibit sections in which coal and carbonaceous shales are exposed. The known details are too voluminous for insertion here, but it may be stated that there is a fair prospect of good coal being found. The most remarkable section is that afforded by the Samasota River, where a sequence, including eight thick seams, is seen bent into a steep anticlinal with gneiss and Talchirs showing at the broken crest.

*Talchir Group.*—Since the publication of the sketch describing the Raigarh and Hingir field, the extension of Talchirs in various directions throughout the adjoining area has been ascertained. More particularly worthy of note is the narrow prolongation of the rocks of this group on the south-east of the field into the immediate vicinity of the Talchir field, thus showing that a connection in all probability at one time existed between the two basins. This prolongation extends for about thirty-six miles, from the Ebe to the Boraghat River. There can be little doubt, I think, that it occupies an ancient valley which was in all probability narrower and of a more defined character during the Talchir period than it is at present. It is not probable that the hills on the one side, or the Bamra plateau on the other, were elevated subsequently to the deposit of the Talchir beds, so that this narrow channel may have been the only means of connection between the Talchir basin and that larger area which extends from Sambalpur over so extensive a tract to the north-west.

In my account of the Bisrampur field,* I stated my belief that the boulders which occurred in the Talchir beds there, most probably came from the north, and it is possible that, in this case, the transporting agent may have travelled from the north-west. At the same time I may say that I did not see anything about the character of the gneiss boulders in the Talchir field to justify the opinion put forward in the Talchir report to the effect that they had probably come from a long distance. So far as I could see, and in consequence of the above opinion I gave particular attention to the subject, the boulder beds of the Talchir field do not contain any materials which might not have been derived from the very great variety of coarse and fine-grained gneisses which are to be found in the neighbouring areas. In the Bisrampur area where boulders of Vindhyan quartzite occur, the case is, of course, quite different. In this connecting strip, except towards the Ebe end, I saw no traces of a boulder bed, the rocks being all shales and sandstones. They seem to be little disturbed from their original position, but at the nearest point to the Talchir field they are cut off by a fault which is not improbably a continuation of the main bounding fault of that field.

During the examination of the older rocks various thin outlying deposits of Talchir beds have been met, not only in the vicinity of the coal-field, but also far to the south of the Mahanadi. In the vicinity of the field, besides the outlier already mentioned near the villages of Tuldi and Terda,† another has been found on the east bank of the Ebe between

* Records, Vol. VI, p. 28.

† Records, Vol. VIII, p. 104.

Ishtapali and Jogipali. Its precise area is somewhat doubtful owing to the way in which it is covered by superficial deposits. Another of small extent exists in the interval between the main Talchir area at Bolunda and the outlier at Terda. South of the Mahanadi and opposite to its junction with the Ebe, just close to the village of Rasem, is a third. It is about half a square mile in extent. Sandstones, shales, and the boulder bed are all represented within these limits.

In the Pal-jor, a small tributary of the Ong River, to the east of the village of Ganislot, the section discloses the existence of a small basin occupied by Talchirs. The rocks consist of sandstones, shales, and a well developed boulder bed with rolling bedding. On the south they seem to rest directly on the gneiss, but on the north the character of the boundary is uncertain owing to the superficial covering. The exact area has not yet been ascertained; it probably does not exceed three square miles. Still further south, in the bed of the Tel River east of the village of Tanigaon, Talchir sandstones are exposed under the bank. On the south they are cut off by gneiss, but how far they may extend to the north-east, up the valley of the Ebe, is not known. Other localities where rocks of this group are reported to exist are at Keutasingha in Patna and Baisasankar in Boad.

### VINDHYAN SERIES.

General lithological resemblance and the relations with other formations are the sole *data* available for correlating the series of azoic sandstones, limestones and shales of the Chhattisgarh and neighbouring areas with the Vindhyan series of Northern India. Already, in a general way, the Karnul series of Madras has been identified with the lower Vindhyan series; but even though the details of the sequence in both are well known it has been impossible hitherto to establish even an approximate correlation of horizons. Such being the case where the rocks have been fully examined, it will be readily understood that with rocks the sequence of which in the wide area of Chhattisgarh is at present a matter of some doubt, no attempt at detailed correlation can be usefully attempted.

Until some complete standard sections have been locally established, comparison with other areas cannot be of much aid in the elucidation of the history of these rocks. But some allusion to the rocks of the same age in the Chanda and Godavari valley districts may become necessary.

Apparently two great groups of these rocks exist, one (A) consisting of a thickness of upwards of 1,500 feet of quartzites, sandstones, and conglomerates resting on shales which latter, in some sections, appear to have been considerably disturbed before the deposition of the upper beds. The relations between the two seem to be in many respects similar to those existing between the upper and lower Vindhyans of the Vindhyan range. What the relations may be which exist between these shales and those of the second group is at present not absolutely known, as no section hitherto examined contains both groups of rocks in their full development; but from their lithological characters and some other considerations to be mentioned hereafter, I am strongly inclined to believe that these shales belong to the second group which seems to be the elder of the two. This second group (B) consists of limestones, shales, and sandstones. The existence of these sandstones interbedded with, and in some cases underlying, the shales and limestones, has been the principal cause of the difficulty which has been experienced in assigning the rocks to two groups, and also establishing the relative position of these groups in the geological sequence. In the following pages, however, sections will be described where sandstones occur sometimes underlying, sometimes interbedded with, limestones and shales; and, on the other hand, sections of what are considered to constitute an upper group, in which there is an unbroken thickness of upwards of 1,500 feet of quartzites, sandstones, and conglomerates resting upon shales as has been above mentioned. In regarding the latter as the younger group my views are, I believe, in accordance with Mr. Hughes' opinion in reference to the similar and very similarly circumstanced rocks of the Chanda district. Before proceeding to describe the physical relations of these rocks, so far as they have been examined, it only remains to point out the geographical areas which they occupy. The largest and most important area is that of the Chhattisgarh basin, the northern boundary of which stretches in a north-west direction from the neighbourhood of Sambalpur, passing Padampur, Raigarh, Bilaspur, and Ratanpur up to the base of the Mandla plateau. Southwards from this with a very irregular eastern boundary, these rocks spread to unknown limits beyond the Raipur district. It is possible indeed that they will be found to be continuous with the Bustar-Jaipur area to be mentioned below. The second area forms a considerable plateau which belongs partly to Nowagarh and partly to Karial. The third is also a plateau, and is situated on the north of the Jaipur district. To the south of this is the fourth area, which is included in both the Jaipur and Bustar districts. Besides these there are rocks of this age near Nowagaon and Ahiri to the south-east of Bhandara.

*Group A.—Sandstones, Quartzites, and Conglomerates.*

Although it is probable that members of this group will be found in the first area, they have not yet been separated in the extraordinarily crushed and disturbed sections of the northern boundary, where there are, especially in the Barapahar hills, rocks lithologically similar to those about to be described. The standard sections, than which no better are likely to be found, are met with in the Nowagarh-Karial plateau. This plateau is of an irregular oval shape, with the major axis running north and south. The area exceeds 750 square miles. The general elevation averages probably about 1,500 feet above the surrounding country, or say 2,500 feet above the sea. Certain peaks are, however, over 3,000 feet high. With a few local exceptions, the quartzites which form this plateau dip inwards away from the gneiss.* On the west, in Nowagarh, the nature of the junction between these rocks and the metamorphics is very admirably illustrated in a series of peculiarly clear sections. In the best of these, in the Japen River at Doarpur and in the Pairi River near Nangabahar, the quartzites are seen at the level of the bed of the river resting directly on the denuded and irregular surface of the granitic gneiss. In the former section the bottom bed of quartzites has in places been eroded, and shows the bare granitic rock within the main line of the boundary. In the latter section the quartzite boundary has, in the bed of the river, been cut back for several hundred yards, and the granite is seen, both on the banks and at the base of a waterfall 20 feet high, underlying the quartzites, the lowest beds of which fill up the inequalities of the surface of the granite. Both to the north and south of the Pairi section, there are outlying caps of quartzite resting on several small granite hills which are situated within from a quarter of a mile to a mile to the west of the main line of boundary.

In these sections, especially in the first mentioned, we find traces of a black carbonaceous shaly bed in association with the quartzites. This bed is of importance, as marking a definite horizon, and will be referred to on a future page.

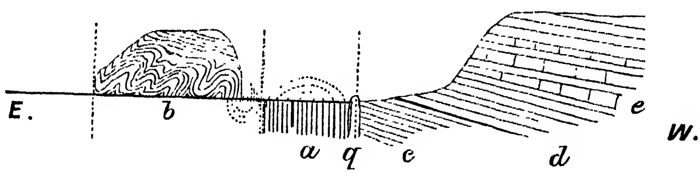
From the Maliva hill round the northern end of the plateau to Tarnot, and thence to Borkot, we do not find exactly the same relation existing, but the boundary is still a natural one. The original bounding rim of crystalline rocks which limited the basin of deposit is here in a great measure still conserved, and the elevation at which the line of junction occurs constantly varies, thus affording evidence of internal overlap between the beds of quartzite along the margins of deposit. In some instances the granite is capped by the higher beds

* A glance at the Atlas Sheet will show the basin-like character of the top of this plateau. The numerous rivers emerge from it over falls and through deeply cut gorges by which their waters reach the level of the surrounding country.

of plateau quartzite at an elevation of 900 feet above the base, and from this amount downwards the levels constantly change, different members of the sequence thus occurring locally as the bottom beds of the group. Of course sections of these rocks in the scarped sides of the plateau are not rare, though many of them are difficult of access. The principal one examined was in the gorge of the Jonk River between Maragura and Jumlagor.

Jumlagor is at the head of a waterfall which is probably 300 feet high. Its elevation is about 850 feet above Maragura, and as the beds forming the plateau are slightly inclined southwards, the ascent traverses the edges of a thickness of beds somewhat in excess of that amount. These beds consist almost exclusively of quartzites exhibiting various degrees of vitrification; the exceptions are beds of conglomerate consisting of small, sometimes minute, quartz pebbles firmly compacted together in a thin matrix. No shaly beds whatever were detected as occurring with these quartzites, which are mostly rather thin-bedded, the distinct layers rarely exceeding 3 feet in thickness. As to the character of the beds of the remainder of this group, *i. e.*, those above the horizon of the Jumlagor beds, I was not able to examine them in detail, but they seem, so far as is known, to be very similar in character to the lower portion. In the internal valley of the Girna River to the south-west of Tarnot, we find dipping under the quartzites of the plateau a group of shales having an extraordinary resemblance to Talchirs, and showing an amount of disturbance which is not shared in by the quartzites of the surrounding ranges. No trace of these rocks was found at the base of the already described western quartzite natural boundary, but on the east they occur in all the deep internal valleys within the outer bounding range of quartzite, and are also found in vertical, apparently faulted, contact with the gneiss close to the eastern base of the horizontal beds which form a small outlying plateau to the east of Tarnot. It will perhaps be sufficient for present purposes to describe two sections which exhibit the relations existing between these beds and the quartzites. These sections are afforded by the gorges of the Under and Udet Rivers.

In the accompanying sketch of the former is represented the relations of the beds as they are understood by me, but the central part of the section is by no means clearly exposed, and may possibly admit of another explanation. The observed facts are as follow:—




Section in the Under River. Horz.: Scale 1 inch = 1 mile.

The section of the outer range is very clearly exhibited on the southern bank of the river. The beds marked (*b*) consist of quartzites with very thin interlamination of red and green clays, these clays being more especially abundant in the central portion of the thickness exposed. The lowest bed seen outside is a quartzite which is much indurated, and which is bent abruptly to the vertical, forming, at least for a short distance, a steep outer face on the hill. After a series of rapid contortions, which do not show, to the same extent, in the beds on the top of the hill, these lower and central beds dip suddenly vertically downwards and do not reappear. Probably, if the rocks were uncovered and visible, we should find that they are brought up by another contortion, as is represented by the dotted lines. A short distance further up the bed of the river we come upon vertical beds of red shales (*a*), which, if not related as represented, would be younger than the quartzites (*b*), a view untenable from the relations found to exist between them elsewhere. That the quartzites (*b*) are bounded by an external fault is most probable. Unfortunately, no contact with the metamorphics is seen, there being no outcrops in the bed of the river for several miles to the east. Both here and all along the boundary of the plateau area from hence southwards to within a short distance of the Udet, the disturbance and constantly varying character of the beds could scarcely be explained by mere lateral crushing. To the north it is possible that a ridge of fault-rock in the metamorphics at Tarnot may mark the continuation of the line of fracture. Regarding the second fault represented, the shortness of the interval between the quartzites (*b*) and the shales (*a*) argues, I think, against the possibility of the whole of the former being brought up by a contortion, and therefore it seems probable that the lower members are cut off by a fault, and that the red shales (*a*), as represented, have been thrust into vertical contact with the quartzites of the central part of the sequence. Passing the red shales (*a*) we come upon a wall-like ridge of pseudomorphic quartz (fault-rock) (*q*) which strikes to about 20° east of north, 20° west of south. Beyond it there are thin-bedded quartzites, shales (*c*), and a black carbonaceous sandy layer (*d*) dipping to from 5° to 10° to west and west-north-west. Overlying these conformably are the saccharine and vitreous quartzites, &c., which form the main mass of the plateau. That this run of fault-rock marks a line of disturbance there can, I think, be little doubt, the more particularly as the thin quartzites (*c*) and shaly beds associated with the carbonaceous layer appear to represent a portion of the contorted beds (*b*) of the outer range. Further, with reference to both this and the previously mentioned fault, evidences of a pair of diverging faults are found for many miles amongst the crushed and disturbed beds in the internal valley to the south. They are also indicated by lines of a breccia abounding with brown hæmatite,* and on one of them is situated a *Hot spring* near Kotagarh. Taken alone, this section, due allowance being made for marginal crushing and fractures, would not be sufficient to prove original unconformity between the beds *c*, *d*, *e*, and the red shales (*a*); but it must be remembered that in other localities where the lower beds are seen in a very disturbed condition close to the base of horizontal quartzites, similar explanation of the relations of the beds by pairs of faults cannot be given.

In the Udet River from Boidelpur westwards there is a section of the lower shales. The first beds seen are red and grey shales, with one bed of quartzite resting on them and dipping at, apparently *under*, granitic gneiss at an angle of 45°. In the northern bank of the river the granite, for about a foot, seems actually to overhang the bed of quartzite. This appearance may be due either to original deposition under an over-hanging ledge or to the effects of a horizontal thrust from the west, probably the latter, as the bounding fault can scarcely have died out again before reaching this point.

Elsewhere I have noted cases of similar beds dipping at the boundary. The river between Boidelpur and Tonkulmal exhibits a nearly continuous section of grey, red, and black shales, with, in places, much infiltrated iron. Besides the above-mentioned bed, no quartzites appear in the bed of the river. The dips are for the most part low to east, east-south-east, south-east. In the hilly country to the south there are quartzites which, at the boundary between Koirpodor and Phulchi, locally dip 80° to east and south-east. Elsewhere they flatten and become horizontal. It seems scarcely probable that they rest conformably on the red and grey shales, but no actual junctions were found.

Finally, it has been established that these shales are older than the quartzites; that they are clearly overlapped is apparent from the sections on the west, in which they do not appear.

* Near Bandi, Kootagarh, and Kudapani respectively.

That they are unconformably overlaid is probable from the amount of disturbance they exhibit as compared with the overlying quartzites. In their lithological characters they correspond with those of some of the rocks of group (*B*) of the Chhattisgarh basin and Jaipur-Bustar area. This resemblance, so far as it is of value, is in favor of the view that the quartzites of group (*A*) are younger than the limestones, &c., of group (*B*). But in addition to this, we have the physical evidence afforded by the fact that the Karial-Nowagarh plateau quartzites occur in their original undisturbed position at a much higher elevation, 1,500 to 2,000 feet above the limestones of the Chhattisgarh basin, the nearest points on the *natural* boundaries of both areas being only a few miles distant.

Again, in the Jaipur-Bustar area about to be described, we have quartzites the base of which is at an elevation of 700 feet above the level of the rocks of group (*B*).

Great faulting in the intervals between the localities where these beds occur might serve to explain these differences of level under the supposition that the quartzites were older than the limestones, &c. But in the absence of the slightest evidence for faulting, the more legitimate conclusion to be drawn seems to be that the quartzites of group (*A*) are really younger than the limestones, &c., of group (*B*).

JAIPUR AREA.—The only other locality in which rocks of the same age as the Karial quartzites have as yet been identified is situated on the north-east corner of the Jaipur plateau to the south of Deobogh. There they rest upon a pedestal of crystalline rocks which is from 600 to 700 feet above the main Jaipur-Bustar plateau, and therefore corresponds in general elevation with that of Karial-Nowagarh. This small plateau, which extends over about 150 square miles, has been much broken up by river gorges in which the crystalline rocks underlying the thin quartzites are at various elevations laid bare. The quartzites, so far as they have been examined, are lithologically similar to the upper beds of the neighbouring Karial-Nowagarh plateau, with which, indeed, it is most probable they were at one time continuous.

*Group B.—Limestones, Shales, and Sandstones.*'

The known limits of the Chhattisgarh basin, the principal area in which rocks of this group occur, have already been roughly indicated. It will only be possible to give here a very brief sketch of what is known of the rocks.

Commencing description from the most eastern point where these rocks occur, and not pausing more than just to mention the fact of the occurrence of several small outliers, we find in the Barapahar hills, a few miles to the west of Sambalpur, an accumulation of shales, sandstones, and quartzites whose relations, not only externally to the metamorphic series, but internally with one another, is of a complicated nature, and which can only be understood after much more time has been devoted to their examination than has hitherto been possible.

This indeed is a region of special disturbance, and one which, when the detailed examination is taken up, would probably be most profitably reserved for the conclusion when standard sections had elsewhere been ascertained. The boundary of this area runs north-westwards, crossing the Mahanadi at Padampur. In some places, massive vitreous quartzites, with bedding obscure or completely obliterated, while in others shales, with occasionally vertical bedding, occur in contact with the metamorphics. Occasionally these rocks dip *towards* the boundary at high angles, a state of things produced probably by intense lateral pressure combined with faulting. In some cases these dips appear to be *reversed*, being produced by the folding over of the beds on themselves.

The opposing edges of the two formations, as exhibited in the Squi River and also in the Mahanadi at Padampur, pretty clearly show that a fault has contributed to produce the relations now existing. In the latter section, the line of fracture traverses the lines of strike of both series of beds obliquely, and in consequence we find in one place the edges of beds of quartzite shales and limestones in opposition to beds of metamorphic rocks, though no actual contact is exposed.

In the neighbourhood of Padampur a considerable section of these rocks is exposed, the lowest occurring in the vicinity of Dungri, where the beds form a partial qua-qua versal dome which is of a very marked character on the north-west of the hills.

The lowest beds seen are sandstones forming a central dome. Resting on these in the valley, there is an unknown thickness of limestones which dip 15° west under the sandstones forming the outer ridge of the hills, where the river changes its course from north to east. Above these sandstones again, in the north to south reach, there is another bed of limestone which is exposed under the east bank; overlying this are red sandy beds which are exposed near the mouth of the Kailo River. Thence up to Padampur, the section in the Mahanadi gives an almost unbroken sequence of shaly red sandstones, &c., with about 100 feet of an externally dove-coloured limestone with numerous veins of calcspar. The dips at first to west turn to north, and close to Padampur are inclined to north-east. At Padampur there is yet another zone of limestone which contains some strings of galena. Under the town the dips are much disturbed, and the rocks are abruptly cut off at the boundary. From the preceding it follows that there are in this section, which includes a thickness of perhaps as much as 3,500 feet of rocks, four distinct zones of limestone, each of which differs lithologically from the others. To the north-west from this the boundary runs with that of the Raigarh-Hingir coal-field, metamorphic rocks being occasionally interpolated.

Mr. Medlicott, in his manuscript report of his traverses of the Chhattisgarh area, has given an account of the sections examined by him along the northern, eastern, south-eastern, and western boundaries from the Mandla plateau to Sambalpur. The principal forms of rocks observed were 1*st*, strong-bedded quartzite sandstones, "often coarse and rusty, often pure and fine;" 2*nd*, "massive, fine, homogeneous clays often affecting a flat nodular structure resembling somewhat the splintery clays of the Talchirs. There are also finely laminated silicious shales; these are often calcareous, and pass insensibly into finely laminated silicious limestones in the manner so common with some of the lower Vindhyan bands of the Son and of Bundelkhand. These shales seem also connected with fine flaky beds very hard and compact (porcellanic) on a fresh fracture, but betraying their flakiness by weathering. These beds, too, find their exact analogues in the lower Vindhyans;" 3*rd*, limestone.—"Limestone is perhaps the commonest rock at the surface all over the plains of Chhattisgarh. It is seldom a pure homogeneous rock, being often flaky and earthy or silicious. Often also the silicious matter is distributed in strings or in irregular concentric concretions.

"It would seem to be only in the most general way that these several rocks observe any order of position. I think all three types may be observed as bottom rock resting upon the metamorphics. But there is a decided preponderance of the sandstones in this position. It would seem that the sandstone never attains a considerable thickness, save at or near the base of the series.

"This variability in the deposits is also a point of similarity with the lower Vindhyans and with rocks described by Mr. W. Blanford in the Godavari area.

"As the most frequent bottom-rock, the sandstones are seldom seen in force except near the boundary, but they are nowhere so much developed as in the south-east, resting on the gneiss of the Jonk area and of Sambalpur, and forming ridges running northwards from that area."

On the south-east boundary only did Mr. Medlicott meet with a "distinct case of simple unaltered superposition." Close to the east of Arang, the shaly, flaggy, dark, silicious limestone shows with a steady inclination of 3° to 4° westward, and on the rising ground to eastwards, the strong-bedded sandstones pass up from beneath the limestone and shales to form a low range of hills. These hills present a gentle slope to the west, and are scarped along the eastern face, in which the junction can be admirably seen of the massive sandstone resting on coarse granitoid gneiss and largely made up of its debris. This debris is not "coarse and water-worn, but gravelly and still undecomposed." Further south in the Pairi River section, I met with the continuation of this marginal bed of sandstones, but I saw no clear indication there that they passed under the limestones. Indeed, from the absence of any distinct dip of the sandstones and the lower level at which the limestones occur, it seemed to me possible that these sandstones might be the marginal remnant of an overlapping bed; but there was, it must be admitted, an interval quite sufficient between the localities where these rocks were respectively exhibited to permit of the sandstones dipping below. Mr. Medlicott has generalised his observations in reference to this and other sections in the following words: "The topmost strata are almost confined to the low grounds where they show the minimum of disturbance, while the bottom bands rise along the boundary and are often much modified by contortion and compression. One has to seek far and wide for proof of the two being really continuous."

The sections on the western boundary present a general resemblance to those of the northern, but the thickness of shales exposed there is greater, and the general character is of course much modified by the presence of overlying basalt. At Warraband, on the Raipur and Nagpur road, the Vindhyans are separated from the crystalline rocks by a bifurcating ridge of quartz, the branches of which strike to north 10° east and north 30° east; the latter possibly marks the position of a fault. East of it are rocks identified by Mr. Blanford (*MS.*) with the Vindhyan sandstones of the Godavari area—"They are hard purplish grits and appear to dip to the eastward at an angle of 10°, but this is far from clear. They continue for a mile or more, apparently with the same inclination, but they are by no means well exposed, and a little beyond (east of) Warraband all the rocks become concealed by soil." "Limestones are exposed in the Mula River, about six miles beyond (east of) Warraband. They are unmistakably identical with the Pem limestones, and they dip at a low angle to east-north-east. A mile further the red Pem shales are seen nearly horizontal, and they continue as far as Nandgaon."

With regard to the general section of lower Vindhyans in Chhattisgarh, Mr. Blanford has written: "Apparently the section of the lower Vindhyans of Chhattisgarh closely resembles that in the Pem Gunga valley. Massive sandstone at the base, then limestone, above shale, upon this apparently rest alternations of thinly-bedded sandstone and limestone. It should, however, be remembered that the rocks are only seen in the Chhattisgarh plains at distant intervals, and that but a very imperfect notion of the section can be obtained without far more careful examination than it has hitherto been possible to give to the ground. Still the general section east of Raipur so exactly represent that to the west that the main sequence, agreeing as it does with that in the Pem Gunga valley, may fairly be considered as correctly ascertained."

Could it be shown that these quartzite sandstones are in the Chhattisgarh area representative of the great thickness of beds in Karial and Nowagarh, then the latter would have in all probability to be regarded as younger than the limestones; but I have already shown that these indubitably rest upon shales—possibly unconformably—whose lithological resemblance more particularly to the Talchir-like shales described by Mr. Medlicott is still stronger than is that to be found between the quartzite sandstones of the two areas.

JAIPUR-BUSTAR AREA.—On the Jaipur-Bustar plateau we find a group of limestones, shales and quartzite-sandstones of precisely similar character to those of the Chhattisgarh basin. It is not improbable that the two areas will be found to be continuous, but the intervening country has not yet been traversed.

In Jaipur the rocks of this group, although they occupy a by no means inconsiderable area, are, for the most part, so much concealed by superficial deposits that it is quite impossible to give anything like a connected section of them. But a few detached points, marking the boundaries, have as yet been fixed; from these, however, it would seem that the limestones and shales occupy a truncated triangular area, which, commencing near the Naorungpur and Jaipur road, spreads westwards into Bustar. It would be useless with the imperfect data at present available to attempt a discussion in these pages either as to the sequence of the rocks or the nature of their boundaries; but from what I saw, I think it not improbable that both north and south boundaries may ultimately prove to be faulted. Certainly I did not see at any of the points examined any clear case of superposition. At Korenga there are sandy quartzites with a dip of 35° to south-west, or away from the crystallines. They are of inconsiderable thickness, possibly the dip carries them under some red calcareous sandy flags which are exposed near Jobra, but the interval between the outcrops is considerable. It is not improbable that the river beds which cross the boundary near Korenga may disclose the nature of the junction.

To the south of Kotepad there is a fairly continuous section of impure grey limestones with red shales, exposed in the bed of the Joura River above its junction with the Ambabal. The limestones dip south 35°. The overlying shales are in places a good deal contorted, but south-east 40° represents the principal direction. Lithologically, these rocks correspond closely with certain beds of the Chhattisgarh basin, as, for example, with some of those above described in the Mahanadi section at Padampur.

In Bustar the rocks seen consisted chiefly of red flaggy nearly horizontal beds of sandy clays; these, at Karinji, are seen overlying quartzite sandstones of, apparently, no great thickness. These beds are in places calcareous, and occasionally impure red limestones occur. I was unable to visit the Chiterkot falls on the Indravati, but specimens brought thence included fragments of vitreous quartzite, and a black shale, like that found at the base of the Karial quartzites.

The examination of the gorge below this fall may not improbably shed a considerable light upon the relations of the beds which constitute the plateau.

From the neighbourhood of Chitapur, which is about sixteen miles to the south-west of Jugdalpur, I received a specimen of a limestone of very similar character to the very pure form already mentioned as occurring at Dongri near Padampur. It is an opaque greyish-white rock with a splintery fracture. A similar rock is found at Korokpur, sixteen miles to south-east of Jugdalpur. Lime is manufactured from this rock in preference to all the other varieties.

## SAKOLI BEDS.

West of Gortalou on the Raipur and Nagpur road there is a section of trap-like rocks, the structural relation of which to other rocks in their vicinity is very obscure. Within the area occupied by them we find also ridges of (? pseudomorphic) quartz-rock apparently similar in character to some found in the adjoining metamorphic areas, where they are, in some instances at least, metalliferous, as will be mentioned further on. One of these ridges is found to the south of the Bagh-nadi bungalow, strike 10° west of north. Before it is reached, however, between the 94th and 95th milestones, there is a bed of quartzose pebble conglomerate which cannot at present be referred to any known formation. The pebbles are mostly of white quartz and 2 to 3 inches in diameter. A similar rock, not improbably the same bed, is met with between the 90th and 89th milestones, and again between the 85th and 84th. In all cases the dip is nearly vertical, and the recurrence of the bed may be due to contortion folds. Trap is seen in the intervals. It is a dense dark-green rock, and save at Burbruj, was nowhere observed to be amygdaloidal. Near the 82nd milestone, the road-cutting exhibits sandy grits and shales alternating with trap in vertical beds. These imperfect observations were made by me under the very disadvantageous circumstances connected with travelling along a road crowded with traffic in the middle of May, and at the rate of fifteen miles a day. They do not, however, constitute the first or only record of this singular group of rocks. They are mentioned by Mr. W. T. Blanford in the manuscript notes of his march from Chanda through the Chhattisgarh country. He writes: "To the east and south of Pallandur* are some hills composed of a singular series of formations which have a very sedimentary appearance, but are, in all probability, decomposed volcanic or trappean rocks of ancient date which it is difficult to separate from the metamorphics, although their mineral character is very unlike that of the hornblend rocks, diorite and syenite, usually found associated with the great crystalline formation of India. In the hills east of Chisgarh, the rock appears to be mainly composed of quartz and felspar. It is pink in colour; associated with it are some red ferruginous shale beds, all evidently much altered as if by weathering. In the Garwai Nadi metamorphics occur, the peculiar trappean (?) rocks forming apparently a hill range along the south bank for some distance, but the road north of the river crosses a mass of the ferruginous shaly rock in one place, and then, about two miles before reaching Chisgarh, ascends a high ghât over crystalline and compact trap, probably the undecomposed form of the rock already specified. At the base of the ascent are some earthy slaty beds, very similar to those seen in the lower Vindhyan sandstones at Nowagaon Tank, but rather more schistose. Some of the traps are amygdaloidal, but I do not think there is any probability of their belonging to any overlying formation; and although it is possible that they belong to a newer series than the metamorphics, they must, I think, until the country is more closely examined, be classed with those rocks."

Mr. Blanford also mentions the occurrence of conglomerates similar to those already described, one of his localities, "two or three miles east of the Bagh Nadi," being probably identical with one of those given above.

### METAMORPHIC SERIES.

In the wide area under description, the bedded metamorphic rocks very possibly all owe their crystalline character to one and the same period of metamorphism; but that they all are the result of the metamorphism of but one uniform series of rocks is most improbable.

Not only is it possible, to a great extent, to separate these rocks into groups, distinguished by marked lithological characters, but if, as seems probable, the bedding structure now seen really corresponds to the original sedimentary sequence, it is scarcely possible to conceive that subsequent disturbance could have produced the relations which are sometimes found to exist between adjacent sections. On the other hand, such relations might very readily be explained by supposing the existence of original unconformity between the beds. By some authorities it is maintained that these so-called beds are due to foliation on the large scale; but when the occurrence in immediate juxtaposition of beds of utterly different composition is exemplified by the cases of limestones next to schists and conglomeritic schists in contact with crystalline gneisses, and when the cases afforded by the less modified sub-metamorphic rocks are all taken into consideration, the conclusion, that the beds now existing

* To the south-west of the road section described above.

*truly represent the order and position of an original sequence seems, to be the more legitimate one to draw.*

*The limits available for the purpose here will admit of only a very brief sketch of the more prominent features of these rocks.*

VALLEY OF THE MAHANADI, FROM CUTTACK TO SONPUR.—Passing westward from the sandstones of the Atgarh basin, along the south bank of the Mahanadi, the rocks seen consist chiefly of varieties of garnetiferous gneiss. These are best exhibited in the Barmul Pass, where the river runs almost due north-west south-east between two sugar-loaf peaked ridges, the dip of the beds being from 40° to 80° to north-east.

Towards Horbonga, and thence to Sonpur, the rocks consist chiefly of coarse porphyritic gneiss, which occasionally shows strikes varying from north-west to west-north-west; but not uncommonly the rock is massive, and exhibits no distinct bedding or foliation.

VALLEY OF THE MAHANADI, FROM SONPUR TO SAMBALPUR.—Between Sonpur and Binka the rocks, where seen, consist, for the most part, of granite, with quartz veins. In the Ong River there are some hornblendic gneisses, and further on, fine-grained bacillary gneisses and quartzites. Close to Binka there is a schistose quartzite, similar to a rock seen in the station of Sambalpur. Its strike is east 35° north, west 35° south, with a dip of 50° to 35° south of east. Further north, at Turam, in the bed of the Mahanadi, there are schistose and granitic gneisses, striking north-north-east, with a dip of 60° to east-south-east: these form the long hill ridges on the eastern bank of the river.

In and near the station of Sambalpur, the rocks are chiefly granitic and porphyritic gneisses, associated with which is a band of quartz schist. The beds are, for the most part, vertical, but in places there appears to be a dip towards the east-south-east. The strike varies from 10° to 30° east of north. A point about three miles east of Sambalpur seems to be the centre of a great synclinal basin, the rocks on all sides consisting of granitic and syenitic gneisses, with schistose and shaly alternations.

AREA NORTH OF SAMBALPUR.—Ten miles north of Sambalpur is the Kudderbuga range, formed chiefly of quartzites, which are much more strongly developed in the western half of the range than in the eastern.

In the Bonum River, south of Katikela, the section exposes a metamorphic conglomerate. The matrix is quite schistose, but very dense and hard, and it includes rounded pebbles of white quartz. The same rock occurs three and half miles further north, in the bed of the Sumpai, south of Dulki. Lodes of brown hæmatite (altered magnetite) occur in the rocks near Kudderbuga, more particularly to north of Rarimoul. The principal one seen there consists of a quartz-iron breccia, which strikes, with the surrounding rocks, to about west 15° north. The ore used by the natives is taken from the washed debris of this lode. Close to Talpuchia there is a small hill of fault rock and *gossan*. It is possible that a metallic lode may exist there. Pebbles of carbonate of lead were found in the alluvium about a mile and a half to the south.

The last section in this tract of country which there is space to notice here, is that afforded by the (Gangpur) Sumpai, a tributary of the Ebe. Close to Kujerma the bed of the river discloses a thickness of 50 to 60 feet of blue limestone, dip 40° south-south-east. Underneath these are somewhat sandy quartzites, and the two rocks taken together are not unlike the Vindhyans seen near Padampur. Nearer the village, however, these rocks appear to be conformable to and dip under granitic gneisses, which are in close proximity; but no actual junction is seen. A portion of the limestone is of inferior quality, containing tremolite; but much of it is a strong pure rock, which ought to prove valuable, should occasion arise for its employment.

The same limestone is seen near the junction of the Sumpai with the Ebe, where it occurs in horizontal beds, abutting against a vein of coarse granite.

AREA IN THE MAHANADI VALLEY TO THE NORTH-WEST OF SAMBALPUR.—In this area, which is bounded on the north by the coal-field and on the south by the Vindhyan rocks, there is a considerable variety of both schistose and granitic beds: of the latter, the most common is a granular-looking, but really finely porphyritic variety. But, perhaps, the leading feature presented by these rocks, especially in the area to west of the Ebe, is due to the presence of several strongly-marked bands of quartzite, which form a series of ridges, with an almost constant strike to north-west south-east. The most remarkable of these is the one which culminates in the Sunari H. S. peak (1,549 feet). The rocks occurring in this hill are protogine granites, covered by the quartzites and blue-and-red sandy schists, which dip to north-east at about 80°. The schistose beds have a decidedly sub-metamorphic aspect, but cannot be separated from the gneissose rocks. On the same line of strike occurs the long ridge of quartzites, which bounds the coal field north of Kudderbuga. There are several parallel ridges to the above, with vertical bedding, which traverse the metamorphic area north of the Mahanadi. In some places these quartzites are quite vitreous; in others, distinctly granular, and not readily to be distinguished lithologically from certain beds of the Vindhyans.

AREA SOUTH OF THE MAHANADI (DUKIN-TIR).—The rocks of this area, so far as they have been examined, consist principally of granitic gneisses, which, however, present no very leading or prominent features, save that in the neighbourhood of Barpali, and perhaps elsewhere, trap-dykes occur in some abundance. Generally speaking, traces of volcanic action in the region under description are of extreme rarity.

PATNA AND BODOSAMAR AREA.—Throughout this area the principal hill formers are several varieties of garnetiferous gneiss. In the neighbourhood of Bolangir there are felspathic granites, which, over a limited area, are characterised by including lenticular masses of limestone, with which wollastonite is often much mixed. Close to the village of Daramgarh, and also at Domaipali, there are graphite schists. The graphite, being merely a constituent of the schist, is of course not of very pure quality. Remarkably fine rock-crystals occur in some abundance near Bijkomar, to the south of Bolangir. They appear to occur in a nest in vein quartz, but no matrix was seen in contact with the nest as at present exposed.

KARIAL AREA.—In the northern part of this area the crystalline rocks consist chiefly of massive porphyritic granites, which are occasionally traversed by eurite veins.

Towards Kumuna a definite strike to about 20° east of north becomes apparent, and the porphyritic granites, which often include pink felspar and a green chloritic mineral, alternate with occasional beds of garnetiferous gneiss.

At Karial town and its neighbourhood the rocks do not continue to strike as above, but from east to west and east-south-east to west-north-west become the prevailing directions. To the east of Karial, at Tukla, and thence towards Ranipur Jural, a fine felspathic slightly garnetiferous granite occurs in bosses, some of which are of enormous size and perfectly symmetrical shape.

The Chaoria hill, to the south of Karial, rises to an elevation of over 3,000 feet, and from a long distance off its massive scarped outlines form a prominent feature in the landscape. This hill, and most of those in the group to which it belongs, is formed of garnetiferous gneiss.

KALAHANDI AREA.—The rocks of the Tel and Hathie valleys in Kalahandi are, probably, to a great extent, similar to those just described; but in the hilly portion of the eastern half of Kalahandi quite a distinct group is met with. They consist principally of hornblendic rocks, being generally dioritic or syenitic; but there are also some crystalline felsites, in which there is no trace of hornblend. The few short traverses I was able to make across the outer ranges of this hilly region were not sufficient to enable me to define the limits of this group of rocks; and owing in a great measure to what I believe to be the origin of the rocks, the sections examined are of a nature very difficult to describe. In some few places, as in the Bodra-jor, these hornblendic rocks appear interbedded with schists and garnetiferous gneiss; but far more commonly the relations are of a most complicated and disturbed nature —one, in short, which can only be explained by regarding a portion of the rocks as intrusive. From the fact that these rocks occur sometimes interbedded with, while at others they envelop and surround, masses of gneiss, *but more particularly from the fact that an obscure foliation structure is sometimes apparent both in the diorites and felsites,* I am inclined to believe that these rocks are the product of original intrusive volcanic rocks, which have been affected by the general metamorphic action of the formation, and are not of plutonic derivation, as might be supposed from their more ordinary lithological characters.

It is impossible to give all the details which I have recorded here. It will be sufficient at present to give the observations made on the longest traverse. The ascent to Moulpatna is effected by a ghât, about 1,235 feet high, in which there is a confused mass of tumbled rocks. What to call the principal form, it is not easy to say. It contains both quartz and felspar, and in places might be called a petrosilex, but it passes into a pegmatite, and is occasionally even syenitic. Towards the top of the ghât, dioritic rocks, with a spheroidal (cannon ball) structure, appear; and close to Moulpatna, gneisses also are seen striking across some of the valleys, and apparently running under peaks and ridges of the diorites. In the section of the Indravati there are coarsely crystalline diorites and syenites, with no distinct sign of either bedding or foliation. Thence, eastward to the Baplaimali plateau, the rocks seen consist, for the most part, of the same rocks, boulders from which strew the surface in every direction. Gneissose rocks, however, occur also, and the plateau is formed of white ashy-looking beds, spotted with magnetic iron. They dip to east-south-east at angles of from 60° to 80°, and are capped by a thickness of 300 feet of laterite. I have once before, in Manbhum, met somewhat similar rocks. In that instance the dioritic rocks, being well exposed, in plan, in a flat country, often appeared to be interbedded with the ordinary metamorphic beds; but frequently they would suddenly leave the steady strike and pass across from between one pair of beds to another, and occasionally also occurred as considerable amorphous masses.

Jaipur Area.—The crystalline rocks of this area belong to three different groups. On the the north-east there appears to be a continuation of the just-described Kalahandi rocks. In the central northern portions there are ordinary metamorphic rocks, which are characterised by including an unusual proportion of hornblendic gneisses. These are well seen in the Boriguma, Poragarh, and Raigarh groups of hills. On the north-west of Jaipur the rocks seem to belong to the group of granites and porphyries of Nowagarh, about to be described. Throughout the whole of the area the rocks are much concealed by laterite and alluvium, and it would be useless to enumerate details here.

Bustar Area.—It is almost certain that crystalline rocks occur in the southern parts of Bustar, and it is not improbable that they will also be found in the north; but as there are none in the portion of Bustar examined by me, we may pass on to the next area.

Nowagarh Area.—Throughout Nowagarh I did not meet with a single completely satisfactory instance of a distinctly foliated or bedded metamorphic rock. Massive granites, syenites, and dioritic rocks have, with rare exceptions, alone been observed. It is a matter of some uncertainty whether these should be regarded as being of metamorphic or true igneous

At the south-west corner of the district I traversed a section of these rocks between Risgaon and Amar, but failed to make out any regular sequence. Ordinary and porphyritic granites, together with some dioritic rocks, alternate, and it is just possible strike north and south with the hill ridges; but there is no distinct foliation or bedding. At Sobha there is a strong north and south ridge, formed of massive granitic porphyry, which is flanked by a dioritic rock on the east. Rocks of this character continue to Borgaon and Puljir, often forming bosses.

The nature of the granite-quartzite boundary has already been described on a previous page.

An extensive group of hills to the south of Nowagarh town consist chiefly also of ordinary and porphyritic granites, which are quite massive and without a trace of foliation. In the Pairi River, between Badomar and the quartzite boundary, there is a long section, in which the principal rock is a massive porphyritic granite, with pink felspar. Towards the north-west corner of the plateau the character of the boundary changes, as already mentioned, the granites running up to an elevation occasionally of as much as 900 feet, *e.g.*, in the Maliva hill, before they are capped by quartzites.

The Lohari hill to the west of Maliva is formed of granites in some variety, many of them being remarkably handsome rocks. One form, which contains both pink and white felspars, includes also epidote and a chloritic mineral; another, which is altogether white, becomes locally pegmatitic, owing to the absence of mica.

Towards Paragaon, further west, these rocks form groups of grotesque-looking bosses and tors. Beyond these again granites are traceable for some miles down the valley of the Pairi, where they occur at the bases of the small plateaus of quartzite and in the lateral valleys. Half way between Bourka and Kukda they are covered up and concealed by these younger rocks, and do not appear again in the country to the west for many miles.

AREA WEST OF THE RAIPUR BASIN.—West of a ridge of pseudomorphic quartz, which crosses the Raipur and Nagpur road at Waraband, there is a zone of crystalline rocks, which extends up to a point two or three miles west of Gortalou, where the above-mentioned Sakoli beds come in. The principal rocks of this zone are massive granites, which form, more especially near Chicholi, numerous bosses and tors. These granites are traversed by a series of more or less parallel runs of pseudomorphic quartz, two of which, and not improbably all, partake of the nature of lodes. The galena lode in the one, four miles to the west of Chicholi, has already been described by Mr. Blanford. This is, I believe, the only locality in India where fluor spar is known to occur. At the time of my visit I could see no traces of galena, the exposed portions having been, I was told, removed by stone-breakers, who were making road metal; but both in that lode and one north of the bungalow at Waraband I found traces of the copper carbonates.

Towards Bandara, and thence to Nagpur, metamorphic rocks, gneisses, and schists are again seen at intervals; but the rocks in the vicinity of the road are, for the most part, concealed by alluvium.

## APPENDIX.

*List of papers by the Geological Survey having reference to the geology of this area.*

### COAL-FIELDS.

Talchir (Blanford and Theobald): Memoirs, Vol. I, p. 34.
Cuttack, coal and iron of (Oldham): „ „ p. 1.
Orissa coal-fields (Ball): Report to Government, 1876.

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| Raigarh and Hingir, 1st notice (Ball) | : Records, | Vol. | IV, p. 101. |
| „ „ 2nd | „ | „ | „ VIII, p. 102. |
| Korba | (Blanford) | „ | „ III, p. 54. |
| Coal east of Chhattisgarh | „ | „ | „ III, p. 71. |
| Atgarh sandstones (Ball) | | „ | „ X, p. 63. |

MISCELLANEOUS.

Geological features of Bancoorah, Midnapore, and Orissa : Memoirs, Vol. I, p. 219.
Sketch of the geology of Orissa (Blanford) : Records, Vol. V, p. 56.
Laterite of Orissa (Blanford) : Memoirs, Vol. I, p. 280.
Lead vein at Chicholi, Raipur District (Blanford) : Records, Vol. III, p. 44.
„ „ „ „ Vol. I, p. 37.

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## ON THE DIAMONDS, GOLD AND LEAD ORES, OF THE SAMBALPUR DISTRICT, BY V. BALL, M.A., F.G.S., *Geological Survey of India.*

### DIAMONDS.

*First discoverers unknown.*

When, or by whom, diamonds were first discovered in Sambalpur is quite unknown. As in similar cases in many other parts of the old world, an impenetrable haze shrouds the ancient discoverers from our view.

Such evidence as exists tends to the belief, that the search for diamonds was carried on, under a rude system, for many centuries before the year 1850, when the British took possession of the district from the late Rajah, Narain Singh.

*Mr. Motte's visit to Sambalpur.*

So far as I have been able to ascertain, the first published notice of the subject is to be found in the narrative of a journey to Sambalpur, which was undertaken by Mr. Motte in the year 1766.* The object of this journey was to initiate a regular trade in diamonds with Sambalpur, Lord Clive being desirous of employing them as a convenient means for remitting money to England.

His attention had been drawn to Sambalpur by the fact that the Rajah had a few months previously sent a messenger with a rough diamond, weighing $16\frac{1}{2}$ carats, as a sample, together with an invitation to the Governor to depute a trustworthy person to purchase diamonds regularly.

The Governor proposed to Mr. Motte to make the speculation a joint concern, in which writes the latter: " I was to hold a third; he the other two: all the expenses to be borne by the concern. The proposal dazzled me, and I caught at it, without reflecting on the difficulties of the march, or on the barbarity of the country, &c."

In spite of his life being several times in danger from attacks by the natives, the loss of some of his followers by fever, and a varied chapter of other disasters, Mr. Motte was enabled to collect a considerable amount of interesting information about the country. Owing to the disturbed state of Sambalpur town, however, he was only able to purchase a few diamonds. After much prolonged negotiation, he was permitted to visit the junction of the Rivers Hebe (Ebe) and Mahanadi, where the diamonds were said to be found. A servant of the Rajah's who was in charge there informed him that "it was his business to search in the River Hebe, after the rains, for red earth, washed down from the mountains, in which earth diamonds were always found. I asked him if it would not be better to go to the mountains and dig for that earth. He answered, that it had been done, until the Mahrattas exacted a tribute from the country ; and to do so now would only increase that tribute. He showed me several

* Asiatic Annual Register, London, 1799.

heaps of the red earth—some pieces, of the size of small pebbles, and so on, till it resembles coarse brick-dust—which had been washed, and the diamonds taken out." *

Lieutenant Kittoe, 1838.

The next mention of Sambalpur diamonds is to be found in Lieutenant Kittoe's account † of his journey, in the year 1838, through the forests of Orissa. He speaks of the people as being too apathetic and indolent to search for diamonds. His remarks on the localities where they occur seem to be derived from Mr. Motte's account, to which, indeed, he refers.

Major Ouseley, 1840.

Although published in the same number of the Asiatic Society's Journal,‡ we find a paper dated two years later, or in 1840, which was written by Major Ouseley, on the "*Process of washing for gold-dust and diamonds at Heera Khoond.*" In this we meet the following statement: "The Heera Khoond is that part of the river which runs south of the islands. The diamonds and gold-dust are said to be washed down the Ebe River, about four miles above the Heera Khoond; but as both are procurable as far as Sonpur, I am inclined to think there may be veins of gold along the Mahanadi."

No mention is made by Major Ouseley of the system of throwing a *bund* across one of the channels, as is described on a following page; but from my enquiries, I gathered that that method of washing was in practice for many years before the period of Major Ouseley's visit. He describes the operations of individual washers—not the combined efforts of the large number, which made that washing successful.

The diamonds found became the property of the Rajah, while the gold was the perquisite of the washers, who sold it for from twelve to fifteen rupees per tola.

Central Provinces Gazetteer.

In the *Central Provinces Gazetteer* it is stated that "during the period of native rule some fifteen or twenty villages were granted rent-free to a class called *Jhiras*, in consideration of their undertaking the search for diamonds. When the country lapsed in 1850, these villages were resumed." So far as can be gathered from the various sources of information, large and valuable diamonds have been occasionally met with; but the evidence on this point is somewhat conflicting. I do not think, however, that what we know is altogether consistent with the statement in the Gazetteer, that "the best stones ever found here were thin and flat, with flaws in them."

Largest diamonds found.

Local tradition speaks of one large diamond, which was found during the Mahratta occupation. Its size made its discovery too notorious; otherwise it would in all probability, like many other smaller ones, found at that time, never have reached the hands of the Mahratta Agent. It is said to have weighed two tolas and two mashas (at ten mashas to the tola),§ which would be about 316·2 grains troy, or expressed in carats 99·3. It would be impossible, of course, to make any estimate of the value of a rough stone of this size, regarding the purity, colour, &c., of which nothing is known.

Another diamond, in the possession of Narain Singh, is said to have weighed about a tola the equivalent of which, calculated as above, would be 45·35 carats. Already one of 16·5 carats has been mentioned as having been sent to Calcutta in 1766. One large but slightly flawed diamond, which I saw in the possession of a native in Sambalpur, was valued in Calcutta, after cutting, at Rs. 2,500. Mr. Emanuel, in his work on Diamonds and Precious

* This description suggests laterite as the matrix from which the diamonds were proximately derived. In this connection it may be noted that one of the principal sources of Cape diamonds is said to be a superficial ferruginous conglomerate.

† J. A. S. B., VIII, 1839, p. 375.

‡ *Ibid.* p. 1057.

§ (One masha = 14·37 grains troy): properly speaking there are 12 mashas in a standard tola.

Stones, gives some particulars regarding the diamonds of Sambulpur, but the limited information at his disposal does not appear to have been very accurate. He records one diamond of 84 grains having been found within the period of British rule, but does not mention his authority. There are said to be a good many diamonds still in the hands of the wealthier natives in Sambalpur. Of course, large diamonds such as those above mentioned were of exceptional occurrence; those ordinarily found are said to have weighed, however, two to four rutties, equal on an average, say, to the thirtieth part of a tola, or 4·7 grains = 1·48 carats. In the Geological Museum, there is at present a diamond which was sent to the Asiatic Society from Sambalpur by Major Ouseley. It weighs only ·855 grs. = ·26 carats.

As is usual, I believe, in all parts of India, the diamonds were classed as follows :—

Classification of diamonds.

I.—*Brahman.*—White, pure water.
II.—*Kshatrya.*—Rose or reddish.
III.—*Vasiya.*—Smoky.
IV.—*Sudra.*—Dark and impure.

Method of washing.

From personal enquiry from the oldest of the Jharas, or washers, at the village of Jhunan, and from various other sources, I have gathered the following details as to the manner in which the operations were carried on in the Rajah's time :—

In the centre of the Mahanadi, near Jhunan, there is an island, called Hira Khund,* which is about four miles long, and for that distance separates the waters of the river into two channels, as indicated on the accompanying map.

In each year, about the beginning of March or even later, when other work was slack and the level of the water was approaching its lowest, a large number of people,—according to some of my informants, as many as five thousand,—assembled, and as the result of a considerable amount of labor threw a *bund* across the mouth of the northern channel, its share of water being thus deflected into the southern. In the stagnant pools left in the former, sufficient water remained to enable the washers to wash the gravel accumulated between the rocks in their rude wooden trays and cradles.

Upon women seems to have fallen the chief burden of the actual washing, while the men collected the stuff. The implements employed and the method of washing were similar to those commonly adopted in gold-washing, save only that the finer gravel was not thrown away until it had been thoroughly searched for diamonds. Whatever gold was found became the property of the washer, as already stated. Those who were so fortunate as to find a valuable stone were rewarded by being given a village. According to some accounts, the washers, generally, held their villages and lands rent-free; but I think it most unlikely that all who were engaged in the operations should have done so.

So far as I could gather, the people did not regard their, in a manner, enforced services as involving any great hardship; they gave me to understand that they would be glad to see the annual search re-established on the old terms. Indeed, it is barely possible to conceive of the condition of the Jharas having been at any time worse than it is at present. No doubt the gambling element, which may be said to have been ever present in work of the above nature, commended it to the native mind.

According to Mr. Emanuel, these people show traces of Negro blood, and hence it has been concluded that they are the "descendants of slaves imported by one of the Conquerors of India." They are, however, I should say, an aboriginal tribe, showing neither in their complexions, character of their features, nor hair, the slightest trace of a Negro origin.

* Lit., Diamond mine.

When Sambalpur was taken over in 1850, the Government offered to lease out the right to seek for diamonds. And in 1856 a notification appeared in the Gazette describing the prospect in somewhat glowing terms.* For a short time the lease was held by a European at the very low rate of two hundred rupees per annum; but as it was given up voluntarily, it may be concluded that the farmer did not make it pay. The facts that the Government resumed possession of the rent-free villages, and that the Rajah's operations were carried on without any original outlay, materially altered the case, and rendered the employment of a considerable amount of capital, then as it would be now, an absolute necessity.

Indian Government become proprietors.

Within the past few years, statements have gone the round of the Indian papers to the effect that diamonds are occasionally found now by the gold-washers of Sambalpur. All my enquiries failed to elicit a single authentic case, and the gold-washers I spoke to and saw at work assured me that the statements were incorrect. Moreover, they did not appear to expect to find any, as I did not observe that they even examined the gravel when washing.

No diamonds found recently.

With regard to the origin of the diamonds, the geological structure of the country leaves but little room for doubt as to the source from whence they are derived. Coincident with their occurrence is that of a group of rocks which has been shown to be referable to the Vindhyan series, certain members of which series are found in the vicinity of all the known diamond-yielding localities in India,† and, in the cases of actual rock-workings, are found to constitute the original matrix of the gems.

Source of the diamonds.

In several of the previous accounts, the belief is either stated or implied that the diamonds are brought into the Mahanadi by its large tributary the Ebe. It would not, of course, help the point I am endeavouring to establish to say that the Ebe, at least within our area, except indirectly,‡ is not fed by waters which pass over Vindhyan rocks, but I have the positive assurance of the natives that diamonds have not been found in that river, although gold is and has been regularly washed for. On the other hand, diamonds have been found in the bed of the Mahanadi as far west as Chanderpur and at other intermediate places, well within the area which is exclusively occupied by the quartzites, shales, and limestones of Vindhyan age.

* NOTIFICATION.—Persons desirous of working the valuable diamond mines of the Mahanadi are hereby informed, that after the 1st of January 1857, the privilege will be leased to any one who shall be considered to have made the most eligible offer for the same.

*2nd.*—Besides precious stones, gold is to be met with in considerable quantities, and the party who may rent the privilege of working the diamond mines will be entitled to appropriate all diamonds, precious stones, and gold that he may find in the bed of that river within the limits of the Sambalpur Division during the period of his lease.

*3rd.*—Unless a proportional inducement be offered, a lease will not be granted for a period of more than three years, but applicants are requested to state at what rate per annum they are agreeable to rent the mines, and how many years' lease they are desirous of obtaining, with particulars of all modifications they may wish made in the conditions now set forth.

*4th.*—Parties proposing to rent the mines must be prepared to lodge in the treasury at Sambalpur one year's rent in advance as security for the fulfilment of the terms of the lease taken up by them, and the rent will be demanded in three instalments yearly. If at any time during the lease, the period of one year, calculated from the date of payment of the last instalment, be allowed to elapse without the payment of an instalment, the security money shall be forfeited and the lease considered to have expired.

† *Conf.* Medlicott, Bundelkund, Mem. G. S. I., Vol. II, p. 65.
  „ Mallet, Vindhyan Series, *id.*, Vol. VII, p. 69.
  „ King, Kadapah and Karnul formations, *id.*, Vol. VIII, p. 87.

‡ By a few small streams which rise in an isolated outlying hill called Gotwaki. It should be stated, however, that one of the tributaries of the Ebe, the Icha, far away in Gangpur, is said to produce diamonds; but the statement needs confirmation, and the geology of that part of the country is at present quite unknown. Near its sources, far away in Chota Nagpur, I have heard the Ebe spoken of as the Hira Nad.

The mere fact that the place Hira Khund, where the diamonds were washed, is on metamorphic rocks, may be readily explained by the physical features of the ground. The rocky nature of the bed there and the double channel caused by the island afforded unusual facilities for, in the first place, the retention of the diamonds brought down by the river; and secondly, for the operations by which the bed could on one side be laid bare and the gravel washed by the simple contrivances known to the natives.

Hira Khund.

It is impossible to say at present which the actual bed or beds may be from whence the diamonds have been derived, as there is no record or appearance of the rock ever having been worked; but from the general lithological resemblance of the sandstones and shales of the Barapahar hills and the outlier at Borla with the diamond-bearing beds and their associates at Panna in Bundilkhana and Banaganpilli in Karnul, I have very little hesitation in pointing to these rocks as in all probability including the matrix. Above Padampur the Mahanadi runs through rocks of this age, and I should therefore strongly urge upon any one who may hereafter embark upon the undertaking of searching for diamonds in Sambalpur to confine his operations, in the first instance, to the streams and small rivers which rise in the Barapahar hills and join the Mahanadi on the south. Besides the obvious advantage of being, as I believe would be found to be the case, close to the matrix, these streams would, I think, be found to contain facilities for obtaining a sufficient head of water for washing purposes. The works would require but a few laborers, and could be carried on for a much longer period every year, say for eight or nine months, than would be possible in the case of the washings in the bed of the Mahanadi itself.

Rocks similar to diamond matrix at Panna and Banaganpilli.

Most favorable localities for future operations.

According to the accounts received by me, the southern channel of the Mahanadi used not to be emptied in the Rajah's time; but from various causes I should expect it to yield, proportionally, a larger number of diamonds than the northern. In the first place, the stronger current in it would be more efficient in removing the substances of less specific gravity than diamonds, while the rocks and deep holes in it afford admirable means for the retention of the latter. Again, it is in direct contact with the sandstones and shales (presumedly diamond-bearing) of the outlying ridge at Borla. Owing to the greater body of water to be dealt with, it would be found to be more difficult to divert than that which flows in the northern channel; but the result in a greater harvest of diamonds would probably far more than compensate for the greater expenditure incurred.

In the country to the south of Sambalpur, in Karial and Nowagarh, where rocks of similar age occur to those of the Barapahar hills, I failed to find any traditional record of diamonds having ever been found or searched for. It is just possible, however, that the names of several villages in which the word *Hira* (diamond) occurs may have reference to some long-forgotten discovery.

Similar rocks further south not known to be diamond-bearing.

In addition to diamonds, pebbles of Beryl, Topaz, Carbuncle, Amethyst, Cornelian, and clear quartz used to be collected in the Mahanadi; but I have not seen either sapphires or rubies. It is probable that the matrix of these, or most of them, exists in the metamorphic rocks, and is therefore distinct from that of the diamonds.

Pebbles.

## GOLD.

In all probability gold occurs pretty generally throughout those portions of the district in which metamorphic rocks prevail. So far as I have been able to gather from personal observation, the washers confine themselves to the beds of the Mahanadi and Ebe; but in the rains they are said to leave the larger rivers and wash in the small jungle-streams.

In the Ebe, below Tahood, I saw a party of gold-washers encamped on the sand. The places where they were actually washing were within the area occupied by rocks of Talchir age; but whether the gold was proximately derived from the Talchirs or had been brought down by the river, as is possible, from the metamorphic rocks, a short distance higher up, I am unable to say.

Gold washed for within Talchir boundary.

There is of course no *primâ facie* improbability in the Talchir rocks containing gold. On the contrary, the boulder bed, including, as it does, such a large proportion of materials directly derived from the metamorphic rocks, might naturally be expected to contain gold. In the original description of the Talchir coal-field the following passage occurs:—"Gold is occasionally washed in the Tikaria River, and was also a few years since obtained from the sands of the Ouli." The latter case is rather interesting, since the localities are in a sandstone country, through which the Ouli mainly flows.* In this connection it may be mentioned that in Australia, quite recently, a conglomerate bed of carboniferous age has been found to be auriferous.†

As to the methods employed by, and the earnings of, the gold-washers, the remarks made in a paper by me on the gold of Singbhum‡ apply equally to Sambalpur, and need not be repeated here.

Method of washing, &c.

LEAD ORES.

*Galena at Jhunan.*—On the occasion of my first visit to Sambalpur in 1874, Captain Bowie, at that time Deputy Commissioner of the district, shewed me some specimens of galena which had remained in the possession of the Tehsildar and other residents since before the occupation of the district in 1850. The history of this galena appeared to be as follows:—

It was discovered in the bed of the Mahanadi at Jhunan, 10 miles west of Sambalpur, in the Rajah's time, and was at first extracted to a small extent by the people and used as a substitute for *Surma* or antimony for anointing the eyes. Suddenly, however, the Rajah, Narain Singh, becoming afraid that the discovery might attract the notice of Europeans, ordered the excavation to be stopped and the lode to be covered up and concealed.

First discovery.

During the 25 years or so which had elapsed since that time, the river has somewhat shifted its channel, and sand and clay had been deposited against the bank where, according to the villager's recollection, the lode was originally exposed. By Captain Bowie's orders, a party of these villagers were set to re-discover the position, and on the 27th December we visited the spot and found that several trenches had been dug in the sand; these, owing to the influx of water and a shifting layer of quicksand, had failed to lay bare the face of rock, but from the fragments of stone brought up it was apparent that the lode had not been struck. The rocks seen in the bed of the river consist chiefly of a coarse granular-looking granitic gneiss, which strikes from about north-west to south-east. Observing some small veins of quartz to run with the strike, it seemed probable that the lode would do so too, and I accordingly laid out a line for a new trench, which resulted a few days later in the re-discovery of the deposit.

Re-discovery.

Among the first specimens of galena brought into Sambalpur was one weighing 1 maund 6 seers 4 chittacks, of which about one-half consisted of galena, the remainder being made up of portions of the quartz gangue and sides of the lode.§ In some of these

* Mem., G. S. I., Vol. I, p. 88.
† *Vide* Geol. Mag., 1877, p. 286.
‡ Records, Vol. II, p. 11.
§ This fine sample is now in the Geological Museum.

first specimens, the presence of antimony was apparent, and there were also traces of the carbonates of copper. On re-visiting the locality, I was able to satisfy myself that the deposit occurred as a true lode which, though striking, apparently with the surrounding granitic gneiss rocks, has a different underlie, and cuts across the plains of their bedding and foliation. At this stage, what I subsequently found to be the case was not apparent, *viz.*, that the lode does not rise to the surface or outcrop of the gneiss above the bed of the river, but that it commences somewhat abruptly several feet below. In the portion of the lode exposed, which was about six feet in length, the distance between the walls varied from 16 to 19 inches. The strike was from 35° north-of-west to 35° south-of-east with an underlie of 45°, to 35° east-of-north, that of the surrounding rocks being in places 60°.

Deposit a true lode.

The gangue consists of quartz, which is permeated in every direction by nests and strings of galena. In places massive ore stretches from wall to wall. Besides hydrated peroxide of iron which forms a kind of *gossan* with the quartz, I found no trace of any foreign minerals in the gangue.

Nature of gangue.

On assay, the galena yielded 12 oz. 5 dwts. of silver to the ton of lead. This, though a small percentage, would be sufficient under favorable circumstances to yield a profit on the cost of extraction.

Silver.

On the whole, the aspect of the lode, as seen at that time in the bank of the river, was so promising that, at Captain Bowie's request, I laid out a system of trenches by which its extension inland from the river might be proved. Subsequently, a small grant of money was made by the Central Provinces Government for the purpose of making some experimental excavation, and operations were forthwith commenced. Just before leaving Sambalpur in April 1875, I again visited the locality to see what progress had been made. I found that a trench about 20 feet deep had been dug through the alluvium some 60 yards from the bank of the river; but it had not been carried to a sufficient depth to lay bare the rock throughout. On this occasion I first found out what I have above noticed, namely, that the lode does not, on the scarped river face, rise to the outcrop of the rock. This, of course, renders the chance of striking it by mere superficial trenches in the rock very much smaller than it would otherwise be.

Preliminary exploration.

In the absence of any one who could take charge of the work on the spot, I did not recommend any operations in the river bed itself, as, if injudiciously carried out, they would not improbably injure the prospects of successful mining hereafter by destroying all trace of the lode and leaving in its place an excavation open to the floods. Such work as had been done was, from the want of skilled guidance, not of a conclusive character. I therefore could not recommend any further outlay being incurred on the exploration, and accordingly nothing more has been done in the matter since 1875.

*Galena at Padampur.*—The above is not the only locality in Sambalpur where galena has been found. Twenty-four miles farther up the Mahanadi, in the bed of the river under the village of Padampur, strings and small nests of galena occur somewhat irregularly in a bed of Vindhyan limestone. This deposit does not appear to exist in sufficient abundance to become of any economic importance.

To the north of Sambalpur, near Talpuchia on the Ebe, some rolled pebbles, consisting of a mixture of the oxide and carbonate of lead, have been found. Whence they were originally derived is uncertain, but I think it possible that the matrix may exist in a small hill to the north of Talpuchia, which consists of fault-rock and *gossan*.

Carbonate of lead.

## NOTE ON "ERYON COMP. BARROVENSIS," McCOY, FROM THE SRIPERMATUR GROUP NEAR MADRAS, BY OTTOKAR FEISTMANTEL, M.D.

Amongst the fossils from the Sripermatur group, near Madras, which were sent in by Mr. Foote, and which contain numerous plant impressions and remains of marine animals, there is also the impression of a fossil Crustacean. The impression shows a portion of the carapace, a fragment of one leg, and the abdomen. The specimen is very flatly pressed, although the adnexa of the epidermis are pretty well marked. From the extremely flat carapace, and from the condition of the seventh segment and of the caudal plates, is shown that our specimen belongs to the genus *Eryon*, Desm.

### CRUSTACEA, DECAPODA, MACRURA.

#### ERYONES, Desm.

*Eryon comp. Barrovensis*, McCoy, Figs. 1, 2, 3.

1849. McCoy: On the classification of some British fossil Crustacea. Ann. and Mag. Nat. H., vol. iv., 2nd series, p. 172.
1858. William Jardine: Memoirs of Hugh Edwin Strickland, London, p. 227 (figure).
1862. Oppel: Palæontologische Mittheilungen I. Uber jurrassische Crustacean, p. 11.
1866. Woodward (H.): Notes on the species of the genus Eryon, &c. Qu. Journ. Geol. Soc. of London, vol. xxii, p. 495, &c., pl. xxv, fig. 1.

In our specimen there is only about one-third of the carapace preserved, very flatly pressed. The lateral margin, as far as can be seen from the preserved portion, was denticulated; the posterior margin is slightly emarginated: at the point of junction of the lateral and posterior margins there seems to have been a somewhat projecting angle. In the median line of the carapace are seen two oblong impressions, which seem to be connected, and of which the lower one, near the posterior margin, is deeper and narrower.

These two impressions answer, of course, to tubercles of the same form on the surface of the real specimen (ours being only a negative impression).

About in the middle between this median series of tubercle impressions and the lateral margin, there is seen another longitudinal slight impression, running in an oblique direction from the posterior margin towards the anterior portion and the median line. This impression must have been caused by a prominent ridge, which had the same direction.

The breadth of the carapace at the broadest part was 44 mm.: of its length I cannot judge. There is a fragment of a leg; and from its size and form, I must judge that it belongs to one of the first pair of legs.

The abdomen is about one-third narrower than the carapace, as far as can be seen from the impression.

Seven segments are well seen. The first is narrower and much shorter than the others: in the median line there is an oblong, deep impression: the lateral portions of this segment are not well shown.

The following four segments are almost equally long, but they get a little narrower towards the seventh segment. Each of these segments shows in the median line an oblong, pretty deep impression and, besides this, two lateral tubercular impressions, quite close to the anterior margin. The sixth segment shows the same condition as the four preceding ones; but is narrower. It continues into the seventh, which is much narrower, but longer, of a triangular form, ending in a pretty sharp point. At its base this segment is a little constricted, but gains again its entire breadth, finishing from thence in the pointed apex.

The lateral margins of this seventh segment are finely and sharply denticulated.

On both sides of the median line of this seventh segment are seen two oblong spaces, beginning broader at the base of the segment, and becoming very attenuated towards the apex; their extension is very well characterised and defined by closely set, sharply marked, minute holes, like pricks of a needle. I suppose these two spaces are the impressions of two similar ridges, which in the living animal were in this place on the upper surface.

On both sides of this seventh segment are the caudal plates, two of them on each side, and they form, together with the median seventh segment, a pentaphyllous caudal fin. These caudal plates are connected by a special intervening segmental portion with the sixth segment. Their form is broadly, sub-quadrately oval; and they are, as far as I can observe, traversed by a longitudinal ridge—in our specimen, of course, very flattened.

On one of the outer plates (in the drawing the right one) I can observe, nearer the apical margin (the extremity), a curved line, which, I suppose, represents a suture in this plate. This would agree with Mr. H. Woodward's observation on *Eryon Barrovensis* (1866, *l. c.*, p. 496), while Dr. Oppel (1862, *l. c.*, p. 9) stated that the caudal plates are undivided, as is, in fact, the case with the forms from the "Solenhofen-Schiefer." Mr. H. Woodward marked this suture in the caudal plates as an *important* distinction of *Eryon Barrovensis*, from the Solenhofen species; and the character must be used to the same extent in our specimen. On the inner caudal plates, I could observe that their margin is finely denticulated. The whole surface of the abdomen, as preserved in our specimen, shows very fine minute holes, which extend also into the tubercular impressions in the median line of the segments. These little holes are only the impressions of little warts which covered the epidermis of the living animal.

The lateral processes (epimera) of the segments are a little decreasing in size towards the last segment, and are rounded in their anterior marginal portion. The process of the last segment is more acuminate; and to this are joined the segmental portions, on which the caudal plates are inserted. These lateral processes show also the minute holes, which I mentioned before to be found on the whole surface.

*Dimensions of the abdomen.*

| | Mm. |
|---|---|
| *a.* From the posterior margin of the carapace to the apex of the 7th segment ... ... | 48·0 |
| *b.* Length of 1st segment ... ... ... ... ... ... | 3·5 |
| *c.* " of 2nd " ... ... ... ... ... ... | ·5 |
| *d.* " of 3rd " ... ... ... ... ... ... | ·6 |
| *e.* " of 4th " ... ... ... ... ... ... | ·6 |
| *f.* " of 5th " ... ... ... ... ... ... | ·6 |
| *g.* " of 6th " ... ... ... ... ... ... | 5·5 |
| *h.* " of 7th " ... ... ... ... ... ... | 16·0 |
| Breadth of the same at base ... ... ... ... ... ... | 11·0 |
| *i.* Breadth of inner caudal plates ... ... ... ... ... ... | 8·5 |
| Length of the same ... ... ... ... ... ... ... | 14·0 |
| k. Length of outer caudal plate from point of insertion to the apex ... ... | 16·5 |
| *l.* Greatest breadth of the same ... ... ... ... ... ... | 11·0 |
| *m.* Distance of suture in the caudal plate from point of insertion ... ... ... | 11·5 |
| *n.* Breadth of 1st segment ... ... ... ... ... ... ... | 28·5 |

COMPARISON.—The very flat and broad carapace, the structure of the seven segments with median and lateral tubercles on the anterior margin, the form and structure of the caudal plates, leave no doubt that our specimen is an *Eryon*. The two most closely related forms are *Eryon Hartmanni*, v. M., and *Eryon Barrovensis*, McCoy. The general resemblance is very close.

ERYON HARTMANNI is figured by H. v. Meyer in N. Act. Ac. Leop. Carol., vol. xviii. pt. i, pl. xi-xii. This species is, however, much larger in all dimensions, although the general form of the carapace would agree. The segments are much broader and longer; the


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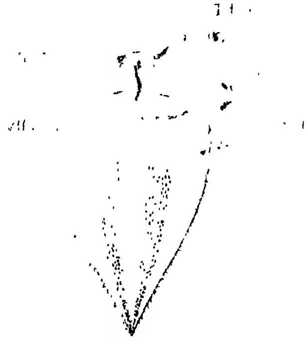

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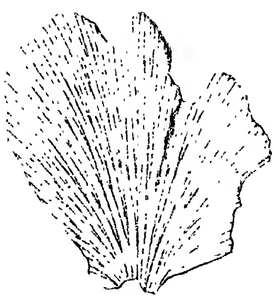

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median tubercles are smaller in proportion to the segments, than is the case in our specimen; the lateral tubercles are hardly marked, while they are distinct in our specimen. The lateral processes in *Eryon Hartmanni* are more decreasing in size towards the posterior segments than in our specimen. The seventh segment is broader in *Eryon Hartmanni*, the lateral margins being more curved. The formation of the inner pair of the caudal plates in our specimen, however, agrees with the same in *Eryon Hartmanni;* the outer caudal plates are not well exhibited in H. v. Meyer's drawings. The surface of the abdomen shows also well the warts of the epidermis.

Our specimen shows, however, a closer resemblance with *Eryon Barrovensis,* McCoy, when compared with H. Woodward's restored figure (*l. c.*): it shows the median series of tubercles in the carapace, and also the lateral oblique ridges; the median and lateral tubercles of the segments; also the lateral processes are identical with those in *Eryon Barrovensis,* McCoy. The seventh segment agrees in general form also well with Mr. Woodward's drawing, although this figure does not show the two longitudinal spaces, set with the minute holes; but in the figure given in W. Jardine's work (*l. c.*), p. 227, the seventh segment shows precisely the same two dotted spaces as are seen in our specimen.

The caudal plates are of importance. One of the outer caudal plates in our specimen (the right in the figure) shows at the extremity, as already mentioned, a *suture,* which H. Woodward has shown also in his figure, and pointed out as an important distinction from the Solenhofen specimens; and the same suture is also shown distinctly in W. Jardine's figure (*l. c.*) This character I consider as most important in the comparison of our specimen with *Eryon Barrovensis,* McCoy. The inner pair of caudal plates is in our specimen broader on the point of insertion than is shown in Woodward's drawing; but in W. Jardine's figure they show almost the same condition.

With the *Eryones* from the Solenhofen-Schiefer, as they are figured in Graf Münster's Beiträge" and in Dr. Oppel's Palæontologische Mittheilungen, our specimen cannot be well compared, most of these having the caudal plates more triangular; but the want of a suture in the outer plates forms the chief distinction.

The genus *Eryma,* Meyer, which has a somewhat similar caudal fin, can, of course, not be taken into consideration, the carapace being different.

*From what I have said, it would follow that we have here a form, which has its closest ally in* ERYON BARROVENSIS, McCoy, *of the English Lias: in fact, our specimen differs from that described by Mr. Woodward only by its being a little smaller (the abdomen is 22 mm. shorter), while it agrees completely in size, &c., with that given in W. Jardine's work* (*l. c.*); *so that there is hardly any objection to consider our specimen as* ERYON BARROVENSIS, McCoy.

As I mentioned, our specimen is from the Sripermatur group (upper Gondwanas), west of Madras, which contains plants and animals, the plants being, to a great extent, of the type of the Rajmahal flora, which I determined to be of liassic age.

This Sripermatur group has its immediate representative in the Ragavapuram shales, on the lower Godávari; and these shales, as described by Mr. King, overlie beds of the age of the Rajmahal group.

*Explanation of Figures* 1—3.

*Fig.* 1—Represents the specimen of natural size, showing a portion of the carapace, one leg, segments, and caudal fin.

*Fig.* 2—Fifth segment twice enlarged, showing the median (m. t. i.) and lateral tubercular impression (l. t. i.), the dotted surface and lateral processes (l. pr.).

*Fig.* 3—Is the sixth and seventh segment together, twice enlarged, showing lateral tubercular impression (l. t. i.), segmental portion (s. p.), and the dotted spaces of the seventh segment.

## NOTES ON FOSSIL FLORAS IN INDIA, BY OTTOKAR FEISTMANTEL, M.D., *Palæontologist, Geological Survey of India.*

### *XVII.—Some elements of the Artic and Siberian Jurassic Flora amongst the plants of the Gondwana-system.*

#### 1. GINGKO. *Lin.* (*Heer*).

Prof. Heer, the illustrious describer of the Artic Fossil Flora, has, in his recent publications, disclosed to our knowledge the Jurassic Floras of Spitzbergen (Cape Boheman) and of Eastern Siberia and the Amur countries. A most interesting fact is, I think, the establishment of the genus *Gingko* (*Salisburia*) among the Jurassic plant remains—a genus which is at present living in Japan and China. Species of this genus are described from Siberia and Spitzbergen.

Some forms of this genus were at first described from the Yorkshire Oolite as *Cyclopteris*, Bgt., *Cyclopteris digitata* being best known. Later, the name *Bajera* was established for these forms by Fr. Braun. Prof. Heer was so fortunate as to receive more complete specimens, from which he proved them to belong to the genus *Gingko*. The fossil representatives of *Gingko* in the Jurassic formation at present known are—

(1) Spitzbergen—Cape Boheman.*

*Gingko digitata*, Heer, with varieties.
*Gingko Huttoni*, H.
*Gingko integriuscula*, H.

(2) England—Scarborough: †

*Gingko digitata*, H. (*Cyclopteris digitata*, Bgt.).
*Gingko Huttoni*, H. (*Cyclopteris Huttoni*, Stbg.).

(3) South-Eastern Russia—Kamenka, near Izoum: ‡

*Cyclopteris incisa*, Eichw.—Closely related with *Gingko Huttoni*, H.
*Gingko digitata*, H. (as *Cyclopteris*).

(4) East Siberia (Irkutsk) and Amur countries: §

*Gingko Huttoni*, H. (E. Sib.).
*Gingko Schmidtiana*, H. (E. Sib.).
*Gingko flabellata*, H. (E. Sib.; Amur c.).
*Gingko pusilla*, H. (E. Sib.; Amur c.).
*Gingko Sibirica*, H. (E. Sib.; Amur c.).
*Gingko lepida*, H. (E. Sib.).
*Gingko concinna*, (E. Sib.).

Forms of this genus were previously also described from Cretaceous and Miocene (Greenland, Senegaglia, N.-W. America, &c.).

* Heer, Flora fossilis arctica, Vol. IV.
† Brongniart, Hist. vegét. foss., tab. 61. f. 2. 3 : Lindley and Hutton, Foss. Flora of Gr. Brit., tab. 64.
‡ Eichwald, Lethaea Rossica, Vol. II.
§ Heer, Flora fossilis arctica, Vol. IV.

I have to record two forms from our Indian Jurassic deposits (upper portion of Gondwana system)—

GINKO LOBATA, Feistm., figs. 4, 5.
*Cyclopteris lobata*, Rec. Geol. Surv., 1876, p. 126.
*Gingko*, Rec. Geol. Surv., 1877, p. 144.

This species is from the Jabalpur group (Sher River in the Satpura basin), and was described by me at first as *Cyclopteris*, before Heer had established the genus *Gingko*. I distinctly pointed out its relation to *Cyclopteris digitata*, Bgt., which itself is now a *Gingko digitata*, H., of which a splendid specimen is figured in the Jurassic Flora of Spitzbergen, pl. x, f. 2, by Prof. Heer.

I saw a difference in our specimen from *Gingko digitata* in its not being so deeply incised, and called it therefore *Cyclopteris lobata*, which name I keep in transferring the form to *Gingko*, but state again, that it is very closely related with *Gingko digitata* from the Yorkshire Oolite (Lower Oolite).

GINGKO CRASSIPES, *sp. n.*, figs. 6, 7.

*Foliis oblonge, rotundatis, basim versus attenuatis, margine indivisis, hinc inde sublobatis, nervis creberrimis repe'ito dichotomis, e basi radiatim eggredientibus, pedicello crassiusculo, linea notato.*

This species agrees in the condition of the leaf with *Gingko integriuscula*, H., from Spitzbergen; our leaf, however, is more oblong: the chief distinction is the thicker peduncle of our species, which shows well the point of insertion. The margin is undivided; here and there slightly lobed. Veins are numerous, repeatedly forked, radiary.

*Locality.*—Our specimens (four altogether) were found in the Ragavapuram shales on the Lower Godavari.

*Gingko lobata*, Feistm., is from the same place, and in fact preserved in the same specimen of the Jabalpur group on which I first saw the *Glossopteris* in these beds, and *Gingko crassipes*, sp. n., is from a group which is on the same horizon as the Sripermatur group, from which I described the *Eryon* comp. *Barrovensis* and as the Kota-Maleri beds.

*Gingko Huttoni*, H., from the Middle Jura in Spitzbergen and E. Siberia, is, according to Prof. Heer's opinion, very close to the living *Gingko biloba*, Linn., in Japan and China.

2. Two other types of fossil plants from the Jabalpur group, which I have not figured in the plates to be published with the descriptions of the fossil flora of that group, are represented in the annexed figs. 8 and 9, as I think they are of some interest.

Fig. 8 shows linear impressions, with oval or round swellings in their length. The drawing represents them rather too distinctly. The only fossil which this specimen recalls, is the recently-described genus *Czekanowskia*, Heer (*l. c.*), which is said to be a conifer, the lineal impressions representing leaves, and the swellings being caused by parasitic fungi. This specimen is from Jabalpur.

Fig. 9 represents a set of lanceolate leaves, apparently converging towards the lower part, as if they should join there. As far as can be seen, they are traversed by longitudinal single veins. This specimen is from the Sher River and recalls Prof. Heer's *Phönicopsis* (*l. c.*).

I do not at present intend to identify the figured specimens with the forms mentioned from E. Siberia and the Amur countries. I wish only to indicate the possible relations, as it may happen that by the discovery of more and better specimens from the Jabalpur group, the identity with those forms will be proved. I point to these three forms specially, as in a general paper they might be overlooked; but the relations of our Indian Jurassic floras with those in Asia are much closer.

If we take the flora of the Jabalpur-Kach group, with the somewhat older flora of the Rajmahal group, then we find its representatives in South Russia (Izoum, near Kamenka), in Immeretia to the south, and Daghestan to the north of the Caucasus, in the Elburz mountains, near Astrabad, in Irkutsk (E. Siberia), in the Amur countries, in Japan, in China, west of Pekin, and in the Province Hoopeh; and, according to Baron von Richthofen's opinion, the coal-beds of Sze-Chwán, Yunnan, &c., are of about the same age. In my paper on the flora of the Jabalpur group I shall discuss these relations more in detail, showing the identities.

### 3. A new Dicksonia L'Herit from the Damuda Series, Figs. 10—11.

In the continuation of the Rajmahal Flora* I have described a *Dicksonia* as *Dicks. Bindrabunensis;* but as at that time I was not aware of Prof. Heer's work on the Jurassic Flora of Eastern Siberia and the Amur countries having been published, I said, page 23, that "we do not find this name as a fossil genus." I am glad to see that, although Prof. Heer was prior in establishing the genus as fossil, I was also correct in my diagnosis, which I made independently.

I have now to record a form from the Damuda series, which is very close to one of Prof. Heer's species. The specimens in question are from the Raniganj and Jherria coal-fields: one of the specimens from the latter locality which were collected by Mr. Hughes, I have figured (fig. 10), and two leaflets are enlarged in figs. 10*a* and 10*b*.

The sub-opposite pinnæ rise from the rhachis, at subacute angles, turning upwards. The chief rhachis and the rhachis of the pinnulæ are traversed by a median line. The pinnulæ are membranaceous, closely set, oblong, attenuated towards the base, pretty acute at their apex, and decurrent on the rhachis.

The pinnulæ, which are closer to the chief rhachis (about 3 or 4) have a sinuately denticulated margin, while those more distant have almost an entire margin, and only here and there the averted margin shows a slight sinuation. The enlarged pinnulæ, figs. 10*a* and 10*b*, show this.

There is a chief vein coming out more from the lower part of the base, but almost at the same spot a secondary vein passes out from the chief vein; besides this, other secondary veins pass out at pretty acute angles and are forked. No fructification is preserved.

There is especially one species in Prof. Heer's work on the Flora of the Amur countries, *Dicksonia concinna* (*l. c.*), page 87, to which our form is closely allied; and Heer's fig. 2, on tab. xvi, approaches very much my drawing, so that I consider both as belonging to the same group.

In fig. 11 is a pinna of another specimen, which approaches still more Heer's drawings.

This is not the only form in our Damudas which is a Siberian element. Prof. Heer describes a *Phyllotheca Sibirica*, to which, as he himself remarks, the *Phyllotheca australis*, McCoy, is most closely allied; but also our *Phyllotheca indica*, Bunb., from the Raniganj group, is almost undistinguishable from the Jurassic form in Siberia.

* Palæontol. Indica, Ser. II, 2, pp. 23, 24.

Besides these, the Jurassic Flora of Siberia and the Amur countries is very rich in forms of the group of *Alethopteris Whitbyensis*, which also is represented in the Damudas, and is again frequent in the Upper Gondwanas.

*Explanation of Figs.* 4 *to* 11.

*Figs.* 4, 5.—Two leaves of *Gingko lobata.*

*Figs.* 6, 7.—Two leaves, with peduncles, of *Gingko crassipes.*

*Fig.* 8.—*Czekanowskia*, sp.

Several leaf fragments, which I believe to belong to this peculiar form.

*Fig.* 9.—*Phönicopsis*, sp.

A specimen, which I refer to this genus.

*Figs.* 10, 11, (10*a*, 10*b*, 11*a*).—*Dicksonia* comp. *concinna*, Heer, pinnæ of natural size and pinnulæ enlarged.

## XVIII.—Notes on Vertebraria, Schizoneura Zeugophyllites, and Nöggerathia.

From the Indian Damuda series originally two species of *Vertebraria* were described, *i. e.*, *Vertebraria radiata*, Royle, and *Vertebraria indica*, Royle,* which, however, represent only one and the same form, the latter being the longitudinal section, the former the transversal section. Both were (1850) placed by Unger† with *Sphenophyllum.* But as this was only an incorrect supposition, we have to keep the original names.

From Australia similar relations are to be recorded. There is described a *Vertebraria australis*, McCoy,‡ which is the only figure of this genus with this name. It is a transversel section, and was compared with our *Vertebraria radiata*, Royle. This *Vertebraria australis*, McCoy, however, was also placed by Unger with *Sphenophyllum* as *Sphenophyllum australe.* As, however, this transferring of the *Vertebraria australis* to the genus *Sphenophyllum* was incorrect, the name *Vertebraria* is to be retained also for this form.

But there is in Dana's Geology (United States Exploring Expedition, 1849, pl. 14) another form, described as *Clasteria australis.* The closer examination, however, shows that *Clasteria australis*, Dana, is to *Vertebraria australis*, McCoy, in the same relation as is *Vertebraria indica*, Royle, to *Vertebraria radiata*, Royle, or, in other words, *Clasteria australis*, Dana, is the longitudinal section of *Vertebraria australis*, McCoy, both representing one species.

We have here therefore a fossil plant from Australia which within four years was described with three different names, *i. e.*, *Vertebraria australis*, McCoy (1847), *Clasteria australis*, Dana (1849), and *Sphenophyllum australe*, Unger (1850); and for which the name *Vertebraria australis*, McCoy, as the original one, has to be kept.

I thought it useful to point to these relations, in order to prevent mistakes, and to show how in some papers on the Australian coal-bearing rocks confusion may arise when *Vertebraria*, *Sphenophyllum*, and *Clasteria* are quoted as three different forms.

I have also to explain another case, the contrary of the preceding, *i. e.*, the correlation or identification of three different forms in comparing our coal strata with those in Australia: I mean the three forms, *Schizoneura*, *Zeugophyllites*, and *Nöggerathia.* A closer examination and comparison of these three forms shows that they are as different as the former three are identical.

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* Royle, Illustr. of the Botany, &c., Him. Mount, 1839, tab. ii.

† Unger gen. et spec. plant. foss., 1850.

‡ Ann. and Mag. Nat. Hist., Vol. 20, 1847.

(*a*) *Schizoneura*, Schimp.—In this form the leaves (portions of the spath) consist of several leaflets, which are long and linear, and attenuated at both ends; by their connexion the spath is produced. Each of the leaflets is traversed by *one single* pretty thickish vein; and the spath, or a portion of the spath (leaf), shows as many single pretty thickish and pretty equally distant veins as there are leaflets joined together.

That the spath is produced by connexion of several single leaflets is shown by the many instances, both in the European Trias and in our Damudas, where the spath partly splits into the single and free leaflets. The stalk of this plant is articulated, and the spath in the joints is "amplexicaulis."

I have not found any drawing of an Australian plant which could be referred to *Schizoneura*.

The characters mentioned distinguish *Schizoneura* unmistakably from *Nöggerathia*.

(*b*) *Zeugophyllites*.—There are noticed two species of this genus: *Zeugophyllites calamoides*, Bgt., from India (Raniganj, Bengal); and *Zeugophyllites elongatus*, Morr., from Australia.

Brongniart, Morris, and Schimper, who very well knew the characters of *Schizoneura*, did not unite *Zeugophyllites* with this genus; on the contrary, compared it with quite other forms. Brongniart, the original describer, says in his Tableau des genres de végétaux fossiles, p. 89* about *Zeugophyllites*: "Sous ce nom j'ai désigné une forme de feuilles *pinnatifides* de Monocotylédones ressemblant à d'áutres feuilles de Palmiers, telles que celles des *Calamus*, des *Desmoncus*, &c., dont les folioles ont plusieures nervures principales et ne *sont pas pliées en carènes* sur la ligne médiane; dans la seule espèce de ce genre fossile les folioles sont opposées comme dans quelques *Calamus*."

Prof. Schimper thinks to recognise in this diagnosis one of the great *Pterophyllum* or *Anomozamites* from the Rajmahal Hills.

Of the *Zeugophyllites calamoides* no drawing exists; but we have a drawing of *Zeugophyllites elongatus*, Morr.† Supposing this drawing is correct (and there is no reason to think that it is not so), the great difference from any known *Schizoneura* must be seen: the veins are much more numerous, and they belong to the *leaf itself*, which is not composed of several leaflets. It recalls strongly certain *Cycadeaceæ*, especially *Zamieæ*, with which would also agree the circumstance, that of the Australian *Zeugophyllites* single detached leaves are so frequently found, while in *Schizoneura* the spaths seem to have been much more closely inserted in the joints. Amongst the fossil *Cycadeaceæ*, we find, especially with *Podozamites* and others, that the leaves are frequently detached.

That *Zeugophyllites* cannot be placed with *Nöggerathia* will be seen from the following:

(*c*) *Nöggerathia*.—Those specimens from the Damuda series which are styled *Nöggerathia*, and those which I have seen from the upper coal measures‡ of Australia, cannot be compared with either of the former two. The leaves of the so-called *Nöggerathia* are oblongly spathulate, sometimes oblongly ovately rhomboidal: the veins passing out from the attenuated base are thickish, and radiate into the leaf surface, several times forked. This character is at least exhibited in all the Indian specimens examined by me. It is evident that these leaves do not resemble either *Schizoneura* or the Australian *Zeugophyllites*; but neither can they be quite well united with what is described as *Nöggerathia* from the European coal measures.

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* Schimper, Trait d. Pal. veget. II, p. 505.

† In Strzelecki, N. S. Wales, &c., tab. vi, fig. 5, 5a.

‡ Above the Marine Fauna.

My opinion is that the forms of our so-called *Nöggerathia* are all *Cycadeæ*, and especially *Zamieæ*, so that in future I will treat them as close to *Zamia*. We conclude therefore that—

(*a*) the Indian *Schizoneura*, is different from the Australian *Zeugophyllites* and the Australian *Nöggerathia*; also from the Indian so-called *Nöggerathia*:

(*b*) the Indian *Nöggerathia* is different from the Australian *Zeugophyllites*:

(*c*) The Indian *Nöggerathia* is more allied to *Zamia* than to any other form.

XIX.—NOTE ON THE OCCURRENCE OF "GLOSSOPTERIS" (?) IN THE COAL-BEARING ROCKS OF ASIA MINOR, AND ON THE OCCURRENCE OF THE SAME GENUS IN THE TERTIARY FORMATION OF NOVALE.

In my notes on the Indian fossil floras, especially those from the Damuda series, I have made no mention of the supposed occurrence of *Glossopteris* in the coal-bearing strata in Asia Minor, nor have I found any mention of it in papers relating to our Damudas or to the Australian coal-beds, nor have I found it noticed in general palæontological works.

There is, however, a paper by Mr. Schlehan: Versuch einer geognostischen Beschreibung der Gegend zwischen, Amasry and Tyrla-Asy, 1852, where fossils are mentioned from the coal-deposits of Amasry. All these plants are genuine carboniferous plants, most of which are specially determined: amongst the ferns, *Glossopteris* is mentioned, but without any specific determination. It is indeed to be regretted that the names only are given, and nothing is said about the plants, and no figures are given, so that no idea can be formed as to the nature of this supposed *Glossopteris*. The carboniferous plants which Mr. Schlehan mentioned from Schünalü and Tyrla-Asy (Amasry district) are the following:—

FERNS.

*Cyclopteris orbicularis*; *Sphenopteris elegans*: *Neuropteris gigantea*; *Neuropteris tenuifolia*; undetermined species of *Sphenopteris, Pecopteris, Odontopteris.*

LYCOPODIACEÆ.

*Lepidodendron aculeatum*; *Lepid. obovatum*; *Lepid. alveolatum*; *Lepid. hexagonum*; *Lycopod. pinnatus*; *Lepidostrobus.*

SIGILLARIEÆ.

*Sigillaria oculata*; *Sigill. alveolata*; *S. sulcata*; *Stigmaria ficoides.*

EQUISETACEÆ.

*Calamites Suckowi*; *Calam. undulatus*; *Asterophyllites*; *Volkmannia*; *Sphenophyllum majus*; *Sphenophyllum emarginatum*; *Annularia fertilis.* With all these fossil plants of real carboniferous character, undetermined species of *Glossopteris* are mentioned.

As nothing has been published since about the collections of Mr. Schlehan, who is an Austrian Engineer, I thought it best to go direct to the source, and wrote to Herr Hofrath von Hauer, Superintendent of the Austrian Geological Survey in Vienna, to obtain some information about the supposed *Glossopteris*. I wrote on the 31st of July, and on the 6th of October I received a letter from Hofrath von Hauer, with another letter by Mr. Schlehan, in which he explains the case, and which shows that the determination of *Glossopteris* wants confirmation. To settle the question, it may be useful to reproduce some passages of Mr. Schlehan's letter to Hofrath von Hauer, and which this latter gentleman was so very kind to send me.

Mr. Schlehan writes (Oberlaibach, 8th of September 1877):—"As you perhaps recollect, I had the management of the opening of coal-mines in that region from October 1842 up to the end of 1843, and had therefore the opportunity of collecting fossils." These fossils, however, arrived in Europe to a great extent very damaged, so that only some of them were of any use. Mr. Schlehan writes further:—"The determination of the Petrefacta was made in Asia with assistance of Bronn's 'Lethæa geognostica' and Göppert's 'Systema filicum fossilium,' the only two works at my disposal there. The paper on Amasry and Tyrla-Asy was ready for publication already in 1844, but it was only published later in the German Geological Society through the aid of the long since deceased, and so deservedly lamented, Herr Leopold von Buch. If you now will take into consideration how many of the Petrefacta in 1842 had different names from at present, and how Palæontology has developed since the date when I went to Asia, it is quite possible that what I mentioned as *Glossopteris* has at present quite a different name."

Subsequently there are some notes by Mr. F. Fötterle on these coal-bearing rocks on the northern coast of Asia Minor,* where these rocks between Eregli and Amasry are classed as Permian, the following fossils having been asserted to occur: *Calam. gigas; Pecopt. Geinitzi; Odontopteris obtusiloba,* these being Permian species. No *Glossopteris* is mentioned. This classification of Mr. Fötterle may indeed, on account of the fossils mentioned, be considered as a correct one; and it is quite possible that, besides carboniferous, Permian is also developed.

But in his great work, Asie Mineure, 1867, Vol. I, Géologie, Mr. P. de Tchihatcheff speaks of these deposits again as carboniferous. The fossils, which he was fortunate to secure from between Eregli and Amasry, were submitted to the competent judgment of M. Adolphe Brongniart; and Mr. Tchihatcheff says, p. 709: "c'est un document important qui, pour la première fois, constate d'une manière rigoreuse l'âge des dépôts houillers situés entre Éregli et Amasry."

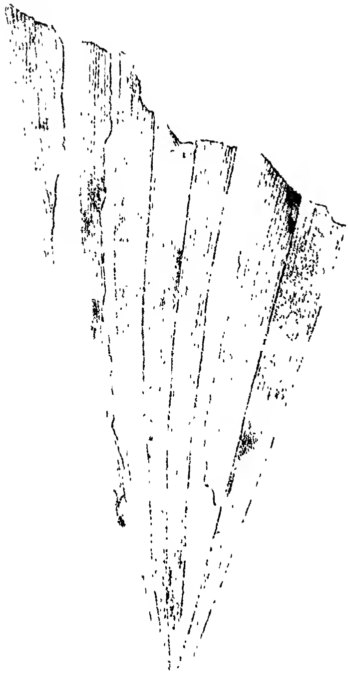
Mr. Adolphe Brongniart determined the following:—

*Sphenopteris; Lepidodendron caudatum,* Stbg.; *Lepidodendron,* near to *Lep. elegans; Sigillaria Candollei,* Bgt.; *Sig. Schlotheimi,* Bgt.; *Syringodendron pachyderma,* Bgt.; *Stigmaria ficoides,* Bgt.; *Lepidophloios; Calamites Suckowi,* Bgt.; *Calam. dubius; Sphenophyllum,* identical with the European species.

Adolphe Brongniart stated that this flora agrees most closely with that of the Rhine basin; but *no Glossopteris* occurred with these plants, which would have certainly been recognised by Brongniart, the original describer of the genus.

Quite recently, however, I observed in the Geological Magazine for July 1877, that a paper was read before the Geological Society by Mr. Spratt, entitled: "Remarks on coal-bearing deposits near Erekli, the ancient Heraclea,"† where, amongst plants of undoubted carboniferous type, as *Lepidodendron, Lepidostrobus, Calamites, Sphenopteris, Pecopteris, Sigillaria, Stigmaria* and *Sphenophyllum,* a *Glossopteris* is mentioned; but again as *Glossopteris* (?). We shall perhaps learn a little more about the impressions mentioned as *Glossopteris* (?) when this paper is fully published. We may notice, however, that the occurrence of *Glossopteris* in the Jabalpur group is not the highest extension at present known of the genus. In their Monograph of the tertiary flora of Novale,‡ Messrs. Visiani

* Jahrbuch k. k. Geol. Reichsanstalt, IX, p. 85.
† More generally known as Eregli.
‡ Mem. d. Acad. di Torino, IId Ser., vol. xvii.



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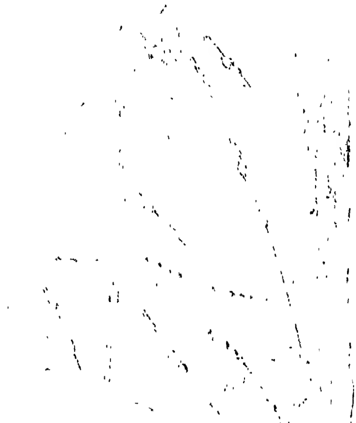

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10 a.

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11 a

11 b

and Massalongo have described, amongst the ferns, a *Glossopteris*, as *Glossopt. apocynophyllum*, on p. 206; and there is a figure of it on pl. I, fig. 1. There is, supposing the figure be correct, hardly any doubt that this form belongs to those ferns with a distinct midrib and areolated venation, which in India and Australia are called *Glossopteris*. It is a strange coincidence that with this *Glossopteris* of Novale broad-leaved species of *Tæniopteris* were found, with pretty distant dichotomous veins, which are as distant as in our *Macrotæniopteris danæoides*, Royle: they were described as *Tæniopt. affinis* Mass. et Vis., and *Tæniopt. crassicosta*, Mass. et Vis.; they, however, seem to belong to one species, which must be classed with *Macrotæniopteris*.

I shall now make some remarks on the affinities of *Glossopteris* with living forms, based mostly on the mode of fructification. In some of the Australian specimens Mr. Carruthers thinks he has observed a fructification *along* the *secondary* veins, which reminds strongly of *Anthrophyum*, with which also the areolation agrees; and already Prof. Ettingshausen* compared *Glossopteris Browniana* with *Anthrophyum Cayenense*, Spr., which is a form of that genus with distinct midrib.

*Anthrophyum* exhibits, however, with similar shape of the leaves, also forms with radiary net-venation, without midrib; and I have already pointed to this case, to show that, perhaps, at least certain forms of *Glossopteris* could be to *Gangamopteris* in the same relation as are the forms of *Anthrophyum* with midribs to those without midrib.

Amongst our Indian forms of *Glossopteris*, I think we have two states of fructification. One is that known in the specimens of Nagpur, which are the typical forms of *Glossopt. indica*, Schimp.; they show a fructification like that in the living genus *Polypodium*. Another form from the Raniganj coal-field I think shows some traces of a marginal fructification, and would recall the fructification of the genus *Pteris;* it is the *Glossopteris angustifolia*, Bgt. The fourth form is the tertiary *Glossopteris apocynophyllum*, of which no fructification is known; but Ettingshausen suggests that it belongs to *Chrysodium*.

Our knowledge of the living affinities of *Glossopteris* stands therefore as follows:—

| Fossil. | Living. | | Observed. |
|---|---|---|---|
| | Order. | Genus or species. | |
| *Glossopteris Browniana*, Bgt. | *Polypodieæ* ... | *Anthrophyum Cayenense*, Spr. | In Australia (Carruthers). |
| *Glossopteris indica*, Schimp. | *Polypodieæ* ... | *Polypodium*. ... | In India (Obs. Brongniart, Bunbury, &c.). |
| *Glossopteris angustifolia*, Bgt. | *Pterideæ* ... | *Pteris*. ... | In India (the author). |
| *Glossopteris apocynophyllum*, Mass. | *Acrostichaceæ* ... | *Chrysodium*. ... | Tertiary, Novale (aut. Ettingshausen). |

There are, of course, many other specimens and forms in which no fructification or any other character to compare them with living forms has been observed. They can no doubt partly be referred to the above-mentioned forms; but there may still be different types.

* Farren der Jetztwelt, p. 25, 1867.

## THE BLAINI GROUP AND THE "CENTRAL GNEISS" IN THE SIMLA HIMALAYAS, BY LIEUT.-COLONEL C. A. MCMAHON.

### I.—THE SIMLA NEIGHBOURHOOD.

On my transfer to Simla from Hissar, the first thing I attempted to do in the way of geology, was to trace the outcrop of the Blaini* limestone round Simla; and I proceed to give as briefly as possible the results of my explorations. The Blaini rocks form such an important clue to the structure of the region around and beyond Simla, as was pointed out in the preliminary sketch of the geology of those hills published by the Geological Survey,† that it may be worth while to record a notice of its position as traced over a large area.

The most convenient starting-point will, I think, be the Lakri Bazaar, Simla. When I arrived at Simla, there was an outcrop visible on the mall, a few yards to the north of the Lakri Bazaar, and another below it on the road leading to Elysium. Following the mall round the north of Jako towards Mahásu, there is a good outcrop on the road side opposite the house called Snowdon, and the Blaini conglomerate is well exposed on the opposite or north side of the road. The limestone crops out again just below where the road to Mahásu branches off from the mall, and thence striking across the mall comes to the surface on a knoll above the house named Holly Oak at an elevation of 7,600 feet.‡ Still proceeding east along the North Jako road, a good outcrop is seen on the road side at the extreme north-east of Jako just where a path descends from the mall to the Mahásu road. Between this point and the exposure of the rock opposite Snowdon, the conglomerate may be seen in numerous places both on the North Jako road and on the Mahásu road below it.

From the point on the north-east of Jako, above alluded to, the Blaini rocks strike down the *khad* in a south-easterly direction and then curve round the flank of Jako, descending by a gentle but steady slope. The limestone passes just above the villages of Sanguti (elevation 6,929 feet) and Chanán (6,600 feet), the outcrop being almost continuous. Thence it winds round the flank of the Chota Chelsea spur above the village of Baláh, and onwards through Malkána and Kamháli to the east side of the Chota Simla spur. It then rises to the crest of the spur and crops out along the top of it until it overhangs some slate quarries. From this point the hills drop rapidly to the bed of the Ussan, and the Blaini rocks have been removed by the erosion which has carved out the valley of that river. The outcrop of these rocks, however, can be traced in a north-westerly direction down to the bottom of the ravine between the two spurs into which the Chota Simla spur bifurcates; and from thence in a south-westerly direction up the opposite side of the spur, being well seen at Chali, Laret, and Jharet.

A little distance beyond Jharet, at a temple above Kwalgarh, the Blaini rocks show again, and then they are cut off by a fault which runs towards the eastern boundary of

* I have followed the modern system of spelling adopted by Government within the last three or four years. The first vowel sound is hard, as in Blind.

† Medlicott: Memoirs, Geol. Surv. India, Vol. III, where the following classification is given of the rocks of this region:—

TERTIARY ... { Siwalik.<br>Nahan.<br>Subathu { Kasauli.<br>Dagshai.<br>Subathu (nummulitic).

Krol.<br>Infra-Krol.<br>Blaini.<br>Infra-Blaini (Simla slates).<br>Crystalline schists and gneiss.

‡ The top of Jako is 8,048 feet. Holly Oak is, according to the Trigonometrical Survey, 7,523 feet.

Jatog; and to pick them up again one has to cross the spur and descend into the gorge of the Sunal River which runs down from the Combermere Bridge, Simla, over the "Water-Falls" into the Ussan. The Blaini limestone shows first on the west side of this ridge under a house called Dâta, near the hamlet of Darmáchi, and thence in a north-westerly direction until it cuts across the bed of the Sunal under the village of Kwára. It is here seen typically resting directly on the Blaini conglomerate. The outcrop may be followed on the right or west side of the Sunal valley as far as Shail, but a little beyond this it is again cut off by the fault above alluded to. Following the line of strike from Shail, one comes on highly metamorphic schists of the Infra-Krol series, and all trace of the Blaini beds is lost. Lower down in the bed of the Sunal the line of fault may be clearly seen, the black carbonaceous Infra-Krol rocks, being on the left bank, brought into juxtaposition with the clear purple and greenish-grey Simla slates, with little disturbance of dip at the line of junction. Higher up the line of fault, the Simla slates have suffered violent contortion.

Descending the Sunal into the Ussan River the Blaini limestone is again picked up on the left bank of the Ussan at Kalog Bag.* Between Shail and Kalog Bag the intermediate rocks belong to Infra-Krol series. From Kalog Bag there are several exposures of the limestone in and adjoining the Ussan until a low southerly dip takes it below the bed of that river. Further on, a northerly dip sets in and rapidly becomes very high. The rocks are nearly vertical in the narrow gorge of the Ussan just below the junction of the Tandalail† stream. The Blaini *limestone*‡ is not exposed here, but the conglomerate is in great force. The conglomerate as seen here deserves, I think, especial study, as an acquaintance with it may lead to the identification of the rock at other places. There are several beds of it—some sparsely, others abundantly conglomeratic. The sub-angular or partially rounded blocks of slaty grit are absent, but the white quartz "eggs" are very abundant. Sometimes conglomerate is very fine-grained, and it probably passes into the Blaini quartzite sandstone. This variety of the Blaini conglomerate is at times much flowered over and pierced by white quartz-veins, and a person not familiar with the rock might easily be led to suppose that its peculiar appearance is wholly due to metamorphic action. A close inspection, however, shows that the rock is a true conglomerate; rounded pebbles of dark-grey or purple quartzite are sometimes freely scattered amongst the white quartz "eggs," and the former at times contain one or more thin white veins which do not pass into matrix, showing clearly that the metamorphism of the contained pebble was effected before it was worn down into its present shape and buried in the matrix.

Following the line of strike which leads at first along the crest, and afterwards along the flank of the spur that runs up from the Ussan River to the peaks above Kyari Ghât,§ the limestone crops out again at Badun. The dip is north-east down into the Tundalail, and the limestone is seen twice between Badun and the stream. In the bed of the latter there is about 60 feet of it, thin-bedded and nearly vertical. It is here, by local contortion, jammed into the dark Infra-Krol slates, and partakes of the colour of the latter.

Following the line of strike from Badun, the limestone is again seen between that village and Basna. Near Basna the black Infra-Krol rocks and Simla slates are seen together. Following the line of junction of the two rocks, I passed over the crest of the ridge and landed at the exposure of the Blaini limestone on the Simla and Kalka

* A little west of Tharala of the map.

† This is the stream marked on the map as flowing down from Dhar, where it has its rise near the Kalka and Simla road, past Tundul of the map.

‡ In the slates at no great distance, there is a calcareous slaty bed.

§ Kyari Ghât is a Dâk Bungalow on the transverse spur a little to the north of Kura of the map.

road near Kyari Ghât (13¾ miles from Simla). About 100 feet in vertical height, below the cart road, the limestone crops out and is exposed for some little distance, and is then lost owing either to a sudden twist in the line of strike or a small fault. At no great distance, however, to the south-west of this point, it crops out again in great force in front of Wákna and shows along the path leading to Mamleg* for about half a mile, and is seen resting directly on the conglomerate. It then crosses from the south to the north side of the spur, and shows almost continuously down to the Chiama hamlets, where conglomerate of the Ussan type is abundant. The strike now becomes north-westerly, and the limestone shows abundantly through the several Chiama hamlets until it is lost in the cultivated fields overhanging one of the tributaries of the Gamber. From this point the Blaini rocks strike directly for the south end of the Syri hills, and though the limestone does not again crop up until the Gamber is reached, the conglomerate can be easily traced under and in immediate contact with the Infra-Krol slates. On the right bank of the Gamber the limestone re-appears, and beds of from 10 to 15 feet in thickness are repeated several times by crushing, the Infra-Krol slates being caught up in the folds. Above the limestone are the black slates of the Infra-Krol series, and below it the conglomerate in all its varieties in great abundance.

From the Gamber there is an almost unbroken outcrop of the limestone through Jabal-Bakesu and Khairi-Bakesu on to Mamleg. On the ascent up to Mamleg, the limestone gets astride on the back of an anticlinal that extends up to the Syri road, and consequently spreads out to a great width. At Mamleg and below it the limestone is seen in great profusion. The extension of this bed in a south-westerly direction would take it to the Syri road above Haripur. On the edge of the Mamleg plateau it is seen overhanging the intervening valley, and a limestone re-appears on the other side. It crops out near Dochi on the Syri road and along the crest of the ridge, and then dips under the nummulitic rocks, as represented by the pisolitic bottom-rock of the Sabathu group. I cannot be certain that this last described limestone (the Dochi bed) is the Blaini rock, but I think it is.

The north-westerly outcrop of the Blaini limestone may be followed from Mamleg until it nearly reaches the Haripur and Syri road. On the road side the conglomerate (the Ussan variety) is seen dipping south-west and north-east. The limestone continues under the road for some distance, until at last it cuts across it close to where a turn in the road brings the Syri Bungalow into sight for the first time. From this point (proceeding towards Syri) the outcrops on the road side are numerous. The limestone is also seen in cliffs below the road, being outcrops along its north-easterly line of dip. The conglomerate of the Ussan variety is here very abundant. The limestone forms the crest of the ridge where the road shifts for a short distance from the east to the west side of the ridge. It finally leaves the road about one mile from the Syri Bungalow, and strikes in a north-westerly direction. There is a constant outcrop through Báma and Barog to Chanog, and thence on to Sharar (Surair of the map), where I shall for the present leave it and return to Simla.

Following the line of strike to the westward from the Lakri Bazaar, the Blaini limestone is well exposed on the lower roads below the bazaar leading from Waverly to the Willows. It there strikes down the hill side and has frequent outcrops until hidden by the wood under the Union Church. It re-appears on the spur about 200 feet below Wheatfield, and from thence the outcrop is pretty continuous to the Simla and Bajji road, which it crosses at an elevation of about 6,500 feet. From this point its course is just under Annandale to the east side of the Yarrows spur, which it crosses at about 600 feet in vertical height below that house. It is well exposed again on the west side of this spur, and it

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* Mamleg is a village on the western side of the little transverse ridge to the south-west of Hamahi of the map. A line drawn from *Sairi* through Hamahi would strike it.

crosses the Chadwick Hill spur at an elevation of about 6,250 feet above the sea. Frequent outcrops may be seen in its onward course, and it is exposed in the ravine about 120 yards below the Chadwick Water-fall. From this point the outcrop is frequent to the crest of the spur running north-west from the Chadwick Hill. The conglomerate is well exposed in some places in this vicinity.

The Blaini limestone is next seen not far from the village of Sarhog, then at Khil, and next in the ravine below Panti. Panti is on a spur running north from the extreme western point of Jatog. From the Chadwick spur the strike of the Blaini rocks is in the direction of the principal town of the Dhámi state, and consequently it crosses the range of hills running north from Jatog some miles from that station. At Dochi* there is a slight outcrop, the dark carbonaceous rocks being above, and the light coloured clay-slates below it. Its course is now *viâ* Kansi, Salána, Bahl, Bitmána, Sar, and thence to Hallog, the capital of the little state of Dhámi. The Blaini rocks cross the ridge about half a mile or so to the north of Hallog, and then curving round in a south-westerly direction are exposed on the western flank of the ridge. The limestone shows well in fields 100 to 150 yards below the village of Ghurrap on the Hallog (Dhámi) and Bajji road; again typically at Piroi; and again on the spur below Piroi to the south-west. The outcrop at the latter place is interesting, because not only are blocks of dark slaty blue limestone seen close to masses of a dirty pink colour, but variegated blocks may be seen, the two colours being exhibited in patches side by side. Between the last outcrop and Pallaini-ka Ghât the Blaini limestone shows in six or seven places. It then cuts across the Dhámi and Arki road at a place called Roh-ke Khal.† It shows profusely under the road, and thence on to Giatu, and further on at Pori, near which village it cuts across the Simla and Arki road. There is no exposure on the road side, but it is seen in the stream (*in situ*) under the road near where the latter crosses the crest of a ridge running down from the Marang hill. The strike is here south-15°-east, and there are several exposures between the last-mentioned outcrop and Jamrog, where it also shows. Its course is now *viâ* Bándla, Patti-ke Ghât, Ghach (Gach of the map), and Kaliana to Sharar (Surair).

From Sharar a branch makes for the hills above Haut. There is a good exposure just above the Koni River near Bánjan, about 2 miles above Bil. It shows abundantly from this to Chakniat and onwards to Ghât on the Syri and Haut road. Its course is now south-20°-west. It forms the crest of a ridge running south from Ghât and then appears in cliffs above Chabal. The Blaini limestone shows on a knoll at Shág, and the conglomerate on a spur further on. The outer outcrop keeps to the edge of the hills bordering the Dún. It is exposed typically in a stream under Baráwari with the conglomerate below it to the west; dip nearly vertical; strike south-22°-east. An upper outcrop above this forms cliffs under Paniáli; caps two knolls above Gori, and forms the crest of the hill on which Patta (the residence for many years of the present Raja of Suchet) is built. At Patta the dip is nearly flat. The limestone is 27 feet, and the conglomerate on which it directly rests is about 40 feet thick. The latter contains oblong boulders 22 and 23½ inches long, and in this respect exactly resembles an exposure on the North Mall, Simla. The conglomerate here is quite typical, but all along this line there is a good deal of the Ussan type also. An extension to the east would take us to the limestone on the crest of the Syri ridge near Dochi alluded to above.

I may note in passing that the conglomerate is always *below* the limestone: apparent exceptions may, I think, be readily explained.

* There are two villages of this name, one north of Jatog, and one near the Syri road.

† Between Gobog and Dhardi of the map.

Following the lower outcrop from Baráwari the limestone shows at a temple (Bijesar Mahadeo), and from thence the outcrop is frequent, and runs *viâ* Thana and Patru to Parála* on the Syri road just above Haripur. The dip is here high easterly, nearly perpendicular. The Sabathu Nummulitics are caught up in a fold of the Blaini rocks which show on either side of them on the Haripur road. The last outcrop of the Blaini limestone on this road is about 300 yards north of the Bungalow, and in an excavation on the crest of the ridge at this spot I found the conglomerate.

From this section, and from another between the Blaini River and the Boj range, I conclude that in *some cases* the Infra-Krol rocks were *totally* denuded before the Nummulitics were laid down. The course of the Blaini rocks to the Blaini River has been already described (*l. c.* p. 31).

In the above pages I have simply described the line of outcrop, but I need hardly say that I have tested my work by examining the rocks above and below the Blaini group. A few general remarks may not be out of place. From the Blaini rocks at the Lakri Bazaar, Simla, there is an apparently unbroken succession of the Simla slates to Naldera (the ridge above Bassantpur), where the limestone series of the Sháli mountain and the Satlej valley begin. The dip is steady, and there is not the slightest trace of an anticlinal. From Dhámi the rocks under the Blaini are the Simla slates, and they extend down until one comes abruptly on the massive limestone of the Satlej valley. From the Blaini rocks on the Simla and Arki road, the Simla slates extend down to the limestone series at Arki. The dip, very moderate at first, soon becomes high, and near Arki vertical.

Regarding the inner (*supra*-Blaini) area I note that the Krol rocks at Jatog are succeeded by the Infra-Krol schists in the downward section, and as the Blaini rocks are neared, the black Infra-Krol slates show prominently whatever direction is taken. Passing from Jatog to Simla the extension of the fault alluded to at page 204 brings up the Boileaugunj schists (Krol quartzite altered), but on the top of Prospect Hill (Simla), and on its west side, there is a dark carbonaceous limestone which, I think, must be one of the bottom beds of the Krol series.

The Jako rocks are, I believe, Infra-Krol. I think this series is about 3,000 feet thick, and that at the Krol and at Jako it either thinned out, or suffered denudation before the Krol series were deposited. Some sections on the flanks of the Chor suggest this view, but to confine myself to the area under description, I would point to the mountain† between Tára Devi and the hills above Kyari Ghát. The foundations of a ruined fort called Mân Ghât exist on the top of it. There are dark carbonaceous slates near the summit, and from the top down to the Blaini beds in the Ussan River the rocks belong, I think, to the Infra-Krol series. There cannot be less than 3,000 feet of them.

The stratification of this mountain belongs to the normal Simla type, *i. e.*, the dip is comparatively flat at the top, whilst the dip into the mountain increases on the flanks. In the river beds the normal condition is for the strata to exhibit indications of violent crushing; the beds being usually vertical and contorted. I have rarely struck the Blaini limestone in the bed of a river without finding it repeated several times by contortion. I am aware that other reasons might be given to account for this normal feature in the Simla area, but I think it may best be explained by the supposition that the present outline of the hills was to a considerable extent carved out before the last series of disturbances took place (as has, indeed, been independently shown, *l. c.* p. 174). This view would, it seems to me, explain the converging dip seen at the Chor, Krol, and elsewhere, as well as the extreme crushing in the low valleys.

* Between Banalag and Kisu of the map.

† On the atlas map a dotted line is drawn down this ridge from the cart road past Shongal to the Ussan River.

The notion might be best explained by a diagram, but it is quite intelligible in words: if a horizontal pressure be set up beneath a deeply eroded surface, any yielding that occurs would be determined along the lines of erosion, as positions of least resistance, comparative rigidity being maintained elsewhere by the weight of the mountain masses. We should thus have extreme contortion in the valleys, extending in diminishing degrees up the flanks of the mountain to the summit, where there would be a minimum of effect. This view would apply to the "transverse" as well as to the "longitudinal" valleys, for in a yielding mass any pressure becomes quaquaversal. The view is, no doubt, opposed to what is often stated in geological text-books, even of recent date, as a sort of axiom—that the contortions observed in strata must have been produced far beneath the surface; but it has been long since shown, in this very neighbourhood, that the extreme disturbance exhibited in the enormously thick Siwalik rocks must have been produced at the immediate surface.*

I think, then, that the converging dips seen so often in the Simla area, accompanied by a rapid increase in the angle of the dip as the valleys are neared, indicate that when the last great disturbance, which has left its marks so deeply on the Simla Hills, took place, the hill area had been approximately carved out into its present outline.

### II.—JUBAL—TAROCHE—CHEPÁL.

The best starting-point for our next excursion will, I think, be the top of Kuper peak, in which the Giri takes its rise. A path from Jubal to Chepál passes some hundred feet below the top of the Kuper, the path rising to an elevation of 10,650 feet above the sea. The rocks exposed along the highest part of the road are the schists *above* the "central gneiss." Along the ascent from Jubal, the dip is about north-east; near the top it is north-11°-east. On the south side where a spur branches off in the direction of Chepál, there is a sudden change in the dip to south-east-11°-east,† and this change brings up the central gneiss at an elevation of 9,620 feet.

I hope to show hereinafter that this is the so-called "central gneiss," but for the present I only announce the fact.

As the slope of the hill side coincides with the dip, the path down to Bamlo (Bomta) runs over the gneiss all the way with the exception of two or three comparatively brief intermissions where the infra-gneiss mica-schists crop up. Bomta is at an elevation of 8,000 feet, and the gneiss shows as far as that village. My political duties required me to visit Taroche (Tirhosh), and the path from Bomta led me in a north-easterly direction down to the bed of the stream. On leaving Bomta, the dip rapidly veered round from south-11°-east to north-east, but the change is masked by grass and trees. In the bed of the stream I came upon thin-bedded calcareous schists utterly unlike the crystalline rocks I had left behind at Bomta. In the light of facts to be subsequently detailed, I do not think I shall be wrong in calling these calcareous schists Krol rocks.

The path up to Taroche (Tirhosh) soon led me above these rocks (below them stratigraphically expressed), and I passed through mica-schist (answering well to the Infra-Krol series) all the way to Tirhosh. After occasional local wavering to the north-north-west the strata settled down to a low north-11°-east dip. The stream below Tirhosh was full of the "central gneiss" boulders, showing the presence of that rock on the southern flank of the Kanchu peak.

From Tirhosh (elevation 6,950 feet), the road to Chepál makes an exceedingly steep descent (some 3,000 feet, I should say) to the stream flowing down from the Kanchu peak.

* Medlicott, 1868: Quar. Jl. G. S., London, Vol. XXIV, p. 47.

† I have not, in any of the bearings I give, made allowance for the variation of the compass.

Dip a little to east of north-north-east. The rocks were at first earth-coloured mica-schists of the ordinary Infra-Krol type, and latterly they passed into a dark bluish carbonaceous slaty schist with a very dark streak. The road now mounted obliquely the eastern side of the spur, running down from the Kanchu peak towards Chepál: and a good way up it, I came on a conglomerate strangely like the typical Blaini rock. Further on near Sartara (not marked on map) I came on limestone reminding me of the Blaini rock. Having crossed the spur, I descended along its western side towards the Simla and Mussurie road, which the path I followed struck between Chepál and Kadi. About two-thirds of the way down to the stream, I came on numerous large boulders of undoubted Blaini conglomerate. I climbed the hill in search of the outcrop, and though I could not find the conglomerate *in situ*, I came upon a limestone answering to the Blaini. It is pink and of a pale bluish-grey. Like the typical Blaini* it is a magnesian limestone, the pink variety containing 34·6 and the grey 28·3 per cent. of carbonate of magnesia.

The next day I searched up the bed of the river for a good exposure of the Blaini rocks, and was fortunate in finding one on the east bank of the stream just opposite where the descent from Chepál terminates, and the Simla and Mussurie road strikes the west bank of the river. I found the conglomerate resting on slates (Simla slates) with a pale grey streak. Resting directly on the conglomerate was a blue thin-bedded limestone from 20 to 30 feet thick; whilst on the latter rested the black Infra-Krol slates with a black streak. The conglomerate here is remarkable for the partial metamorphism it has undergone. The matrix, more of a schist than a slate, is internally of a light grey colour, but it weathers to a dark bluish-grey. The boulders of what would in the Simla section be the slaty grit are here a quartzite, of various sizes and shapes, ranging in colour from white to pink and to a dark grey. The conglomerate is flowered over with white quartz-veins, which occasionally penetrate the contained boulders as well as the matrix. I have noticed instances of this in the Simla section.

From a careful study of the outcrop exposed in the bank of the river, I think it is beyond all reasonable doubt that the rocks there seen are the Blaini rocks. The limestone and conglomerate seen on the previous day on the eastern side of the spur being in the line of strike with the rocks exposed in the river and on the western side of the spur, must also be the Blaini rocks. The limestone crops out on the west bank of the river, and may be traced up to the Simla and Mussurie road. Beyond this I had not time to trace it. I dare say it runs a short way up the valley of the river which (*vide* map) flows down from the Chor past the southern base of the Chepál spur into the Shallu River.

Before taking leave of this section, let us visit Chugna (Khagna) at the head of one of the branches of this river on the south-west side of the Chepál spur. It is at an elevation of 6,900 feet, and is not less than 3,000 feet in vertical height above the outcrop of the Blaini rocks in the Shallu River just described. Serai (Serañ†), which is nearly south of Khagna, is 7,250 feet above the sea. The dip is flat between the two places, but at Khagna a low north dip sets in. On the Serai road, about 2 miles from Khagna, there is a band of dark-blue limestone of no great thickness which may be traced a long way towards Serai,

* I analysed two specimens selected at random from two typical exposures in the Blaini River with the following results:—

| No. 1. | | No. 2. | |
|---|---|---|---|
| Silica | 8·6 | Silica | 8·3 |
| Iron | 5·9 | Iron | 5·4 |
| Carbonate of lime | 49·9 | Carbonate of lime | 49·7 |
| Do. of magnesia | 36·4 | Do. of magnesia | 35·8 |
| | 100·8 | | |

† Serañ (silent n) is a demon who resides somewhere in the Chor. Our Mahomedan Munshis always write it Serai; and suppose that the word means a resting-place for travellers.

and which must, I think, be a Krol rock. Below it (I examined the descending series for about 1,500 feet in vertical height) are carbonaceous shaly schists and slaty schists which become somewhat chloritic. Above the limestone are silicious and garnetiferous mica-schists, which possibly belong to the "central gneiss" or crystalline series of rocks, and if so, we have here an instance of the extreme unconformity I believe to exist between these two great divisions of our rock-series.

I return now, after this digression, to the Blaini rock left in the Shallu River 3,000 feet below. The Blaini beds there dip north-west at a considerable angle and are repeated two or three times by contortion. On the ascent up to Chepál, the dip drops to 15° north-11°-west and north-north-west. At Chepál the dip is north. The rocks on the Chepál, Paternalla (Patanála) and Daha (Dhár) ridges, along which the Mussurie and Simla road winds, have been conjecturally identified (*l. c.* p. 41) as the Infra-Krol and Boileaugunj (Krol quartzite) series. If this view is correct, and I feel sure it is, the Blaini rocks must pass under these schists and ought to crop out between Dhár and the Giri. Accordingly where the road crosses the Chota Nadi (the stream which flows down from Patanála past Ghodna to the Giri), I observed numbers of boulders of the Blaini conglomerates in the bed of the stream.

I availed myself of the first opportunity I could get to search the bed of the Chota Nadi for the Blaini rocks, and I found that the conglomerate cuts across its bed about 2 miles above the bridge on the Dhár and Simla road. The conglomerate exactly resembles the conglomerate below Chepál. There are the large pebbles or boulders of the dark quartzite answering to the slate-grit of the Simla sections; and there are the white quartz eggs which in this section at times, as in the Ussan River, form a prominent feature of the rock. Not far from the conglomerate I found a thin bed of limestone. From this point the conglomerate crops out freely, rising gradually from the river, and rounding the spur facing Tikera* (Sanj), whence its course is up the left or east side of the valley of the Giri, I met several outcrops of limestone along this section. I left the conglomerate in cliffs high up on the east side of the valley, and as it was clear from the run of the strata that it must soon strike down to the Giri, I continued my search for it along the bank of that river. I found that it cuts across the Giri about 1½ miles on the Sanj, or south, side of Bagain. The slates are here perpendicular, and those on both sides of the conglomerate have a black streak which appear to indicate that the Blaini rocks have been jammed into the Infra-Krol slates. The boulders in the conglomerate are well rounded, and in places are so loosened by the action of water that it required a careful inspection of the rock to satisfy me that I was not looking at river boulders entangled in cracks in the slates; but after a deliberate examination of the rocks, I felt satisfied that I had got hold of my old friend. Above the conglomerate the rocks are dark slates, till about one-third of a mile beyond Bagain,† where mica-schists begin. After this there are mica-schists and silicious schists all the way to Kot (Kot Khái‡). They are an exact counterpart of similar rocks at Simla, and clearly belong to the Infra-Krol and Boileaugunj (Krol) series. The average dip is east-north-east, sometimes 34°, at other times low. Below the conglomerate the rocks are Simla slates all the way along the road to Tikera (Sanj).

## III.—Máhasu, Mattiana, and Shali Hills.

Our starting-point for this excursion shall be Thiog. The old Mattiana road rises to the fort of Thiog (a fort on a peak to the north of the Dâk Bungalow), keeps along the

* There may be a village of this name, but Sanj is the name by which this halting place is known to Natives and Europeans.

† Bagain is on the road somewhere between Shilo and Choal of the map.

‡ Kot Khai is the principal town of the tract of country marked Kot Khai in large letters in the map It is on the upper Giri.

crest of the ridge, and then passes to the east of a mountain-top that rises beyond. The Hindustan and Tibet road runs at a lower level on the western side of this ridge; a spur, called Kaleri-ki-Dhár, runs nearly due east towards the Giri. On the crest of this spur the Blaini conglomerate crops out (dip 24° north-east-11°-north). It is the counterpart of the outcrop below Chepál. Where first struck, it would require an eye trained to the Blaini rocks to identify it, for it is much overgrown with lichen and flowered over with quartz-veins. Further along the ridge it is more easily recognised, and the white quartz eggs are abundant. Though the matrix is hard, I was able in some cases to extricate the rounded boulders of quartzite almost entire. The matrix is of a whitish-grey colour and of schistose texture, and, in some blocks, the pebbles and boulders are so abundant that it was difficult to get good specimens of the matrix. Here, too, some of the quartzite pebbles are traversed by fine quartz-veins that do not extend into the matrix. One large block of rock I found with one face smoothed down and polished so as to show beautiful sections of the white quartz eggs which were abundant in the slab. This is undoubtedly the Blaini conglomerate, and it is *in situ*. The outcrop coincided with the crest of the ridge for a little distance, and then edged away from it down the flank of the spur. The strike of the bed would, if followed down the precipitous descent to the Giri, lead to the outcrop on the bank of that river already described.

In the opposite direction the line of strike would lead to the Hindustan and Tibet road somewhere near the 20th mile from Simla, but the line passes through a forest and I have not noticed any outcrop. Below the conglomerate (*viz.*, in the direction of Thiog) for some little distance, the rocks are slates (Simla slates) with a light grey streak. Dip east-north-east. Above the conglomerate are the Infra-Krol slates. Some of the latter are quite black. Following the road towards Mattiana, the Infra-Krol schists dip at first north-east 39°, but they subside into a low north-east-11°-north dip. These schists lead up to and dip under a strong band of quartzite which begins to show where the road rises to the crest of the ridge. This can be none other than the Krol quartzite.

Some distance further on, the Hindustan and Tibet road passes over to the western side of the ridge, whilst the old road, still used by pedestrians, keeps to the eastern side. We will follow the old road. The rocks exposed are quartzites and silicious, slaty, and micaceous schists, until about 2½ miles from Mattiana, when a bed of bluish-grey limestone, about 3 feet thick, crops out. Dip east-north-east. As Mattiana is neared, the schists become feebly calcareous. A little beyond Mattiana, they pass into calcareous chloritic schists, and in the line of cliffs facing, and some two or three miles beyond, the Dâk Bungalow, these schists become full of iron pyrites, generally in the form of minute cubes. These calcareous chlorite-schists contain from 6 to 14 per cent.* of carbonate of lime. The variety full of iron pyrites is a very curious rock. From the partial segregation of the calcite and the chlorite it often assumes a highly foliated structure. There are also numerous veins of white calcite in it. It weathers a deep brown. It has dawned upon me latterly that these rocks, and there is a considerable thickness of them, must be the Krol limestone *highly altered*.

But to return to the Blaini rocks. There is a thin bed of limestone on the top of the cliffs above Runi. The point is called Tikka. Elevation 9,280 feet, dip north-east-11°-north. The temple (Nág Devi) there is marked Kolu temple on the map. This rock is a magnesian limestone, and rests on a bed greatly resembling the matrix of the typical Blaini conglomerate. Under it is a quartzite band which forms a line of cliffs. Below Tikka there is a village on the map named Barana. A little distance to the east of this village, I came upon an extensive outcrop of conglomerate of the typical Blaini River type. Associated with it was a strong quartzite and a dolomite containing 33·8 per cent. of

* I was careful to select fair specimens for analysis that would not show an unduly high percentage.

carbonate of magnesia. Dip east. These rocks seem in the line of strike of the conglomerate at Thiog, and I think they must be the Blaini rocks. I may here mention that north-west of Thiog and 1,600 feet in vertical height below the Dâk Bungalow, I found a block of the Blaini conglomerate of Thiog type (whether *in situ* or not I cannot say) in the bank of the stream close to a thin-bedded limestone dipping north-north-east. In the bed and bank of the stream little below this is an intrusion of trap of the Mandi type.

In the opposite direction from Thiog, *viz.*, near Sanj (Tikera of the map) there is also evidence of the Blaini group. Sanj is as nearly as possible 3,000 feet below the Thiog Dâk Bungalow. On the crest of the hill overhanging, and a few hundred feet in vertical height above Sanj, is limestone. Below the latter are the Simla slates. On the road from Sanj to Fágu, as long as the road clings to the flank of the spur running down from Thiog to the Giri, I saw numerous blocks of the Blaini conglomerate on the hill side, indicating its presence somewhere above. Further on, on the next spur, there are numerous outcrops of limestone resembling the Blaini. On the ascent up to Fágu, the dip is about north-east. These outcrops correspond with the horizon of the outcrop of the conglomerate on the opposite or east side of Giri valley.

Now a word or two about the Sháli. This great limestone series extends from the Sháli to the Fágu and Thiog ridge. On one occasion I followed the line of the Nowle Gad* River from the two Daoti villages up to Thiog, and I found massive limestone cliffs of the Krol type on both sides of the valley, extending, as far as I could judge, right up to the Fágu-Thiog ridge. Along my actual route limestone beds cropped out continually all the way up to Thiog. Following the Hindustan and Tibet road from Fágu, these limestones crop out over the road about 1½ miles, from the Fágu Bungalow, and the outcrop is from this point pretty continuous for about 2 miles. In one place the limestone forms a cliff on the crest of the ridge. It is greatly crumpled, and seems to have been subject to enormous lateral pressure. Thin-bedded slaty limestones appear again in the road side-cutting a quarter of a mile beyond the Thiog Dâk Bungalow, and show well where the old Mattiana road branches off. They crop out frequently on the road up to the fort, and that structure is built on them. From this point they cut down in the direction of the Sháli and are seen on the sides of the Hindustan and Tibet road a little beyond the 19th milestone. These rocks may be seen forming cliffs below on spurs extending towards the Sháli. On the eastern side of the Thiog Fort, they crop out for some distance (about a mile) along the ridge running down to the Giri and form cliffs under Janti Devi, a temple which crowns a point on this spur. I did not encounter them after this on my way down to the Giri.

Proceeding from the Sháli in a direct line to Simla, the limestone extends across the Nouti, and crops up for a considerable distance on the spur, up which the road to Mashobra† winds, and then they suddenly give place to the Simla slates. I explored the ravine running down from Mahásu, between the two Daoti villages to the Nouti until stopped by impassable cliffs. The average dip is 20° to 23° south nearly all the way down. When the Nouti is neared there are indications of intense crushing, and then the rocks turn sharp down to a northerly dip, and from this point to the Nouti they continue to dip at a high angle. In the descending sections at first are the Simla slates; then comes 80 or 100 feet of pale blue or greenish limestone; under this are dark schistose slates with strings of quartz in them (a very common feature in the Infra-Krol schists), and then the black "crush rock." Thin-bedded blue limestones follow; the dip then gets flat; there is evidence of great crushing, and then the black carbonaceous rock re-appears with white calcite irregular veins in it. This

* Probably a misprint for Nouti, the name by which I found the river known on the spot. Gad seems to be the corruption of Gar, the vernacular word for river.

† Mashobra is the bazaar on the neck of the spur that runs north-west from the Mahásu spur to the Satlej.

rock is here a dense slaty rock almost as black as coal. The section above described strongly suggests the idea of a fault.

This leads to the important question, are the Shâli rocks Infra-Blaini or Krol? It might seem at first sight to follow from many of the facts I have recorded that these rocks are Infra-Blaini. If the Shâli were Infra-Blaini then our sections would run thus—

| | | |
|---|---|---|
| SIMLA ... | Prospect Hill ... / Boileaugunj | Krol. |
| | Jâko ... ... | ... Infra-Krol. |
| | North Jako Road ... | ... Blaini. |
| | Mahâsu ... ... | ... Simla slates. |
| | Fágu to Thiog ... | ... Shâli beds. |
| | Thiog to Mattiana | ... Simla slates. Blaini series. Infra-Krol. Krol. |

In such a section the anticlinal would be required in the Shâli beds and would be drawn from Shâli to a point between Fágu and Thiog. There are serious objections, however, to the adoption of this interpretation which I am not able to get over. In the first place, the axis of the anticlinal must be drawn, if drawn at all, from the Simla end of the Mahásu ridge to the top of the Shâli: *2ndly*, whilst we have a great thickness of Simla slates at the Simla end of the section, there does not appear to be a corresponding thickness at the other or Mattiana end: and *3rdly*, we should after all have to summon a fault to our aid to get rid of the damaging fact of the presence of the Blaini rocks at Sanj and to the north-west of Thiog.

The alternative interpretation—the adoption of the Shâli rocks as Krol—*necessitates*, however, the belief in the existence of a fault between the Shâli and Mattiana (somewhere near Runi); in another between Náldera (the ridge above Basantpur) and Simla; and in a series of faults, or a sort of circular fault, in continuation of the Náldera fault, running round to Arki, and probably on to Kakkuhatti! It is rather appalling to have to adopt such a theory, but I do not see my way out of it.

## IV.—NARKANDA—KOTGARH—RAMPUR.

In my last we travelled as far as Mattiana and for a few miles beyond. From the point we then reached to Narkanda and on to Kotgarh, the schists, micaceous and silicious, are somewhat undeterminate in character, but looked to me more like the younger series than the old. A few hundred feet—500 or 600 it may be—below Kotgarh, there is a thin band of blue limestone which extends for some distance. Under it and down to the stream that divides Kotgarh from Kumharsen, the rocks appeared to be the carbonaceous, micaceous schists of the Infra-Krol series. The dip at Kotgarh is low and northerly, but wavers about from north-north-east to north-west and even more westerly. On the road down to Kapu (Kepu) (on the Satlej, due north of Kotgarh), some of the cultivated fields near Shawat have that peculiar black soil so often seen in the Simla section in the neighbourhood of the black "crush rock." I observed this feature in other places in this direction. As the Satlej is neared we come first on mica schists and then on the "central gneiss." At Kapu (elevation 3,125 feet), the dip of the gneiss is 40°-north-11°-west.

Following the other road from Kotgarh to the Satlej, *viz.*, that to Nirth, we have first slates; then carbonaceous slates; then the gneiss alternating with slates. From Nirth to the Nogli, which flows into the Satlej a few miles south of Rampur, we have slates alternating with the gneiss; sometimes one showing, sometimes the other. Regarding the slates

I noted in my journal, when as yet I had formed no theory,—"They are often carbonaceous, and closely resemble the slaty schists above the Blaini rocks."

From the Nogli to Rampur and beyond, there is an extensive intrusion of trap which has tossed the rocks about a good deal. From Rampur to Nirth the dip, at first westerly, changes to east, then to south, and then back again to west.

Following the upper road from the Nogli to Narkanda, on rising from the Satlej, we come on white quartzite, then dark carbonaceous slates and schists, and in these, a little under Kumsu, there is a thin bed of blue limestone. It is not crystalline. A little above Kumsu the "central gneiss" begins. Again on this road, just below the Sungri Bungalow (on the ridge near Shimál of the map), on the northern side of the ridge, a blue sub-crystalline limestone appears. The outcrop being in cultivated fields, the immediate "allure" could not be made out. Elevation of Sungri, 8,675 feet.

The facts to be stated further on have an important bearing on the question of the nature of the contact of the Krol with the older crystalline series, but I think it will be more convenient to discuss that question now. The view I have formed is that the Krol, Infra-Krol, and Blaini series were laid down on a denuded surface of the crystalline rocks, and that the line of contact has been masked—

(*a*). By the subsequent metamorphism of the younger rocks, at the point of contact, in the *wet* way;

(*b*). By the subsequent compression of the two series against each other.

That the younger rocks often appear to be conformable to and to dip under the older rocks I fully admit, but is it *possible* that this conformity can be real? Are we to believe in an inversion extending along a great part of the line of the Himalayas? Or are we to believe that the "central gneiss," and at least 6,000 feet of mica schists on the top of it, are really younger rocks than the Simla slates? If they are, by what means has the metamorphism of the younger rocks been accomplished? Heat, the product of pressure from above, and heat, the result of plutonic action from below, seem to be put out of court, by the fact that the *lowest* rocks which ought to have been the most changed are the least altered.* Metamorphism in the wet way seems to me equally out of the question. Can we suppose that during the vast ages required for the gradual metamorphism, by the slow wet process, of the great thickness of strata we have to deal with, the Simla slates would have remained as unchanged as we see them at this day?

But may not the observed facts be rationally explained in the way I have suggested? A glance at the map will show—and I hope to explain this in detail further on—that the dip of the older strata is often low, and at times perfectly flat. It does not seem to require a great demand on our imagination therefore to suppose that the younger rocks were laid down upon and against the flat strata of the older rocks; and if the plane of junction of the two series were often more or less steep, would not the subsequent compression of the two together lead to the idea of conformity, especially if the younger rocks at their point of junction with the older had been considerably metamorphosed? That the Krol and Infra-Krol rocks have, as a matter of fact, undergone extensive metamorphism has been pointed out by others (*l. c.*, p. 34); and that this metamorphism has been produced in the wet way is indicated by the fact that it is extensive in the porous top schists and stops short at the impervious clay slates.

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* Heat, the local product of tangential pressure, seems to have been *left* out of court.—H. B. M.

## V.—Shankan and Hatu Ridges.

In Section II we got as far as Kotkhai. I will make this our new point of departure. The road from Kotkhai (elevation 5,790 feet) passes over the Shankan ridge* at an elevation of 9,500 feet, and then drops down to Deora (elevation 6,600 feet), the capital of the Jubal state. The dip at first north-east changed to east-north-east, and then back again to north-east. The angle of dip, generally low, became flat at Deora. About a mile on the Kotkhai side of the Shankan ridge, a thin bed of "central" gneiss appears. Between it and Kotkhai, mica-schists, and occasionally silicious schists, prevail. I found it impossible to say where the Krol (Boileaugunj) schists and the Infra-Krol rocks ended and the crystalline series began. As far as outward visible signs went, there seemed no break in the conformity of the two series. On the crest of the ridge, I found a very thin bed of slate with a dark streak which seemed carbonaceous. I have observed this feature in other places well within the area of the crystalline rocks. These outcrops always seemed very thin, lenticular and local. Down to near Deora, the rocks are fine-grained mica-schists. One bed above the gneiss seems to retain its character all over the crystalline area. It is a fine-grained mica-schist that splits readily into large slabs, and is much used for roofing purposes. One slab I measured—and I give it as a fair sample—was *one inch* thick by 5 feet 8 inches long and 4 feet 2 inches wide. Viewed edge-ways, quartz seems to predominate, whilst the flat splitting face presents an unbroken surface of mica. On the descent there is a strong dyke of trap, the exact counterpart of the trap near Banellah on the flank of the Chor. As Deora is neared we come on the central gneiss, which is here a bed about 50 or 60 feet thick. It runs right round the head of the Deora valley, as indicated on my map.

The principal characteristic of the "central" gneiss is that it is always more or less porphyritic. In its lowest form the crystals are small and lenticular. As the metamorphism advances, they become large and eye-shaped: in the next stage, they take the form of blunted cubes. The next advance is to assume a perfectly rectangular form. These crystals are usually *about* 1½ inches long, but sometimes (as in the Chor), they attain a length of nearly 3 inches. As the metamorphism advances, the axes of the crystals begin to point at an angle to the plane of foliation, and the angle gradually increases up to a right angle. Finally, they point in all directions, and all trace, or nearly all trace, of foliation is lost. When the rock arrives at this stage, all signs of bedding disappear, and the gneiss weathers out into large rounded masses after the fashion of true granite, and becomes very dense and hard to break. The porphyritic felspar crystals appear to be orthoclase; twin crystals are not uncommon. An intensely black mica is another characteristic of this rock. It is a variety, I think, of Biotite. It takes no notice of concentrated sulphuric acid (cold), but continued boiling in this acid extracts all the iron of which the colouring matter consists. The rock also contains a silvery mica which is usually quite subordinate to the other.

We will now leave Deora for the present and return to Kotkhai. Our route thence will be up to Deori, the capital of the little state of Kanati. From Kotkhai to Deori the dip is east-11°-north, then north-east, then east-11°-north again, in mica-schists and silicious schists. On one occasion I went by a direct mountain path from Deori to Deora. I struck the "central" gneiss above, and to the east of Deori, and again just above Deora. The bed passes under the mountains from the one point to the other. The outcrop in the Kanati (Deori) valley takes the form of cliffs, and can be followed by the eye right round the head of the valley. My last trip in this direction was up to the head of the valley, and along the ridge which crowns the valley, to Bági and on to Narkanda. I struck the gneiss just above Thanári (Tharan, I presume, of the map), at an elevation of 8,300 feet, where it is seen extending for miles on either side in the form of cliffs. The outcrop is here about 100 feet

* Shakondhar of the map. The road from Kot to Deora is marked on the map.

thick. There is a second outcrop above it at an elevation of 8,800 feet, which extends (in thickness) up to 8,940 feet. I cannot say whether the bed extends from the outcrop at 8,300 feet up to 8,940 feet, as the intermediate space is well clothed with grass and the numerous blocks of gneiss on it may or may not be *in situ*; but I think the more probable explanation is that the bed has here thickened out to about 640 feet.

The gneiss was seen striking in the direction of the Bágí road, but my path lay along the north side of the ridge at the head of the Kanati valley, at a high elevation, and I had to walk for some miles therefore before the gneiss cut across my path. I came on it again at an elevation of 9,300 feet (this is the elevation of the path—the crest of the ridge is higher), and from this point it formed, for a long distance, the crest and side of the ridge. The gneiss is here at times very granitic. My path left the gneiss at an elevation of 9,375 feet. I note here that the Hattu gneiss is simply an extension of this bed in the line of dip, which is very low. Owing to a bend in the line of strike caused by a change in the dip from east-11°-north to east-south-east, and finally to south-east-11°-east, the gneiss ceases to crop out along the ridge from this point; and the underlying mica-schists take its place along the crest of the ridge and form the picturesque rugged peak facing you at Bágí. Where the path I followed struck into the road running north from Bágí, the dip is 8° south-east-11°-east. Another bend in the direction of the strike brings down the gneiss again a mile or two further on. The elevation of the road at the outcrop is 9,300 feet. The mica-schists, just before the gneiss appears, owing to local crushing, dip north-east, east-north-east, and even north-west. The outcrop of the gneiss continues for 1½ or 2 miles, when the mica-schists re-appear, dipping east to east-south-east: 4 or 5 miles further on, the gneiss shows again on the road side, and continues for some distance, half a mile it may be.

These two outcrops demand a few words in detail. In the first of the two, on the Bágí road, the gneiss has passed into an almost perfect granite of a finer grain, and even more advanced type than that of the Chor. It is only here and there, especially towards the northern side of the outcrop, that signs of foliation can be detected. When I first visited this peak, called by the natives Kot (it rises to a considerable elevation above the road, and is a very prominent object viewed from Hattu and other places round), I had not seen the outcrop described above. Kot looked very much like true granite, and I was at first tempted to suppose that its core had been protruded, in a more or less plastic state, through the mica-schists. These rocks were seen dipping easterly on both sides of the granite and fringing the granitic core below the road. At the top the granite seemed to overlap the schists. Having now visited this mountain three times, and carefully studied it each time, I am perfectly satisfied that it is simply an outcrop of the central gneiss in an advanced stage of metamorphism. Signs of foliation are, here and there, visible, it sends out no intrusive veins* into the neighbouring schists, and the latter are not altered at the point of contact with it. It is simply a bed of some 500 or 600 feet thick, the dip of which, for some distance, coincides with the slope of the hill, and the strike of which, for some distance, coincides with the direction of the ridge. The outcrop, 4 or 5 miles further on, is unmitigated gneiss. I have dwelt at some length on this outcrop, because I think its right interpretation will help us to explain the Chor.

The ridge running from Hattu past Bágí to Kot must, I think, form the south-east slope of an anticlinal which has carried the central gneiss down to the Satlej. Proceeding from Kot to Hattu, the dip is south-east-11°-east, then south-south-east (probably quite local), and on the flank of Hattu east-11°-south. On the very crest of the ridge rising up from Bágí to Hattu, there are rocks dipping north-east-11°-north to north. From Hattu down to Kotgarh the dip is unsteady, but seems to have a general north-easterly direction.

* I only observed one or two very thin veins in the gneiss.

At Kotgarh the general dip is low northerly, whilst at Kapu, the gneiss dips north-11°-west. These facts seem to indicate an anticlinal bend from the crest of the Hattu-Kot ridge down to the Satlej. If this is not the case, there must be a fault, for that the gneiss seen along the left bank of the Satlej, between Kapu and the Nogli River, is a continuation of the gneiss seen on the crest of the Hattu-Kot ridge, I see no reason to doubt.

### VI.—Sungri—Rampur—Sarhan—Sangla.

To get over the ground I must now be very brief and bald. From the outcrop of the gneiss 4 or 5 miles beyond Kot, there is nothing to record as far as Sungri. The rocks are micaceous and silicious schists. Elevation of Sungri 8,675 feet. Dip south-east. The Hindustan and Tibet road between this and Sarhan having fallen into decay, the road from Sungri plunges down into a very deep ravine, at the bottom of which the gneiss shows itself again. True dip about south-east. Beyond Dalog* the gneiss is again reached, and it continues for a long way. It gives place to mica-schists, but at Báli (Barl of the map), elevation 8,000 feet, the gneiss again crops out. Dip, eliminating local variations, south-east, all the way. The "central" gneiss continues to show down the descent to the Satlej as far as Kamsu. Dip, where road strikes Satlej, south-11°-west. From this point there is trap of the Mandi type for about 2 miles (the trap shows best in the bed of the river which I crossed and recrossed frequently on *massaks*). Schists resembling the Infra-Krol series show after this, and then the trap again. The strong quartz beds are burst asunder and twisted about by the trap in a wonderful manner. From Rampur (elevation 3,600 feet), the road rises to Gaora (8 miles, elevation 6,520 feet). Dip usually flat. Quartz-rock predominates for a long way; there are also micaceous and hornblendic schists. Near Gaora we have chloritic and talcose schists, and then gneiss, the foliæ of which are much crumpled. It only shows its small porphyritic crystals at right angles to the foliation.

To Sarhan, 11 miles, elevation of road 6,775 feet, the dip is rather low and north-11°-east most of the way, but veering round to north-north-west at Sarhan; rocks, mica-schists and gneiss, hornblendic, chloritic, and talcose schists. Near Sarhan crumpled gneiss. The rocks are more than once repeated owing to the windings of the road in and out of the side valleys. This is a common feature in the sections exposed along the Satlej valley.

Sarhan to Taranda,† 14 miles; elevation of Taranda, 7,200 feet. Dip at first north-11°-west, afterwards north-north-west, with an occasional waver to north-west-11°-north. Near Taranda there are indications of great disturbance, the dip changes to north-north-west, then to west-south-west, then to west, then suddenly to south, with a high dip that soon becomes vertical. Then we come on three or four strong bands of hornblende-schists. Four miles beyond Sarhan the gneiss passes into a fine-grained whitish granite (only the gneiss altered) and then back into gneiss. From this point the "central" gneiss passes backwards and forwards from a porphyritic gneiss into a porphyritic and highly granitoid rock. Small dykes of the albite granite now become more and more frequent. Near Panuda there are beds of hornblende-schist turned up perpendicularly with the gneiss, which hard bye dips 37° to south-west. After this the dip was north-west-11°-north, north-11°-west, north-north-west, and finally settled down into north.

From Wangtu, owing to the complication arising from the frequent eruption of the granite, the gneiss runs into great masses of granitoid texture, and I could not make out the direction of the dip for many miles; where the bedding of the gneiss could be discovered, it dipped north-west-11°-west, further on, the dip appeared to be north-east-11°-north.

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* Either Naora of the map or a village close to Naora.

† This is, I think, about a mile to the east of Nanaspar of the map, just to east of *Station*, 7,362 feet.

At Wangtu there is a bed of hornblende-schist which, I think, is an igneous rock in an advanced stage of metamorphism. It varies from 2 to 40 feet in thickness and traverses the granitoid gneiss, the bedding of which at Wangtu is obliterated. Sometimes two dykes run a parallel course, at varying distances from each other; at other times one dyke only is visible. It appears to be composed of hornblende and a triclinic felspar, and it shows distinct traces of a foliated structure. The manner in which it expands, or contracts, bifurcates and twists, seems only explicable on the supposition of its intrusion.

I was fortunate enough not to miss *the* minerals of the Satlej valley—beryl and kyanite: the latter I found in the central gneiss, and the former in a dyke of albite granite. What is noticeable about the beryl is that I found crystals piercing a patch of mica, a crystal imbedded in the felspar, and another in quartz, showing that it was the first crystal to become solid in the melted mass. Another specimen which I unfortunately broke was curved, which seems to indicate that the beryl crystals remained plastic for some time.

The trip up the right bank of the Satlej, which will take us to the scene of great granite intrusion, I leave for the present, and turn up the Baspa valley. I followed the right bank of the Satlej as far as Chagaon, crossing to the left bank below that village, and thence on to Kilba, elevation 6,525 feet. From Kilba to Barwa on the Baspa River (elevation 6,600 feet), dip steady north-east until three-fourths of a mile from the mouth of the Baspa, where there is change to 48° east. The gneiss through which I had passed all the way from Wangtu is now lost, and thin-bedded quartzite and mica-schists take its place. To Sangla (elevation 8,650 feet), the dip, at first east-south-east, afterwards varied to east-11°-north and east-11°-south. The angle, at one time as high as 45°, dropped rather suddenly at Sangla to 20°. At Sangla, blocks of the "central" gneiss indicate the neighbourhood of that rock. One end of the bridge rests on a block of gneiss 47′ × 41′ × 15′. The fall of the bed of the Baspu is 250 feet per mile.

## VII.—Rupin Pass—Chansel Ridge—Pabar Valley.

From Sangla I ascended to Nuru,* and encamped on the snow at an elevation of 13,125 feet above the sea. It was at the very end of November. Shortly after leaving Sangla, I came on the "central" gneiss. Dip east, and some crushing aud contortion near Nuru. From Nuru to top of pass (elevation 15,480 feet, Gerard), dip low to east, then flat all the way down to Básuddár† (elevation 11,600 feet). Snow all the way, but rocks well seen in cliffs—they are mica-schists passing at times into gneissic beds. The latter, however, is not the central gneiss, or anything like it. Básuddár to Jako; elevation 8,950 feet. Dip flat all the way. Rocks mica-schist and silicious schists, getting more and more silicious as Jako is neared. Jako to Kuar (Pajearl‡ of map); elevation 7,640 feet. Mica-schists all the way. With some local variations, the dip is flat as far as Pandárgár (Gar = River). This is the Barabati of the map—a name I could not get any one to comprehend. After this the average dip is low to north-11°-east.

Near Kuar there is a compact weathered limestone with some carbonaceous rocks disintegrating into black earth. From Kuar down to the river (a considerable descent), and up to Dodra (elevation 8,300 feet) on the other side, the rocks are mica-schist closely resembling those of the Infra-Krol series. There are irregular strings of quartz in these schists (as in the Infra-Krol rocks), and the earth resulting from their disintegration is dark. Dip

* A halting place under the rocks about three miles on the north-east side of the pass.

† A halting place nearly under the Goras peak, or thereabouts.

‡ Properly Pujiari, so called because there is an idol temple there and a Pujári. Kuar is the collective name of three or four villages, and is the only name by which the place is known to people at a distance.

about west-north-west up to Kála Páni, a halting place in the forest at an elevation of 9,175 feet. Rock ordinary mica-schists. Dip moderate to north-north-west. I now crossed the Chansel peaks (elevation of pass 12,825 feet), and descended to Larot (Lorot of map), elevation 8,480 feet. Mica-schists all the way, gneissic at top of pass. At Larot (8,480 feet) the "central" gneiss is reached. Its course from this point is in a north-easterly direction down to the Pabar River, and then up again on the other side of the valley.

The elevation of Sangla, as before mentioned, is 8,650 feet. The gneiss cropped out, I should say, about 1,500 feet above it (I did not take the actual altitude). The elevation of the outcrop at Larot is 8,480 feet. There cannot be a difference in elevation of more than 2,000 feet between the two outcrops; and unless there are faults, of which I am ignorant, the central gneiss must pass right under the snowy peaks to the south of the Baspa River, and there must be fully 6,000 feet of mica-schists above the "central" gneiss.

Again, if the rocks between Kuar and Dodra are the Infra-Krol rocks, they, like the Infra-Krol rocks between Kapu and Rampur on the Satlej, closely overlie the gneiss, and rest, as I have suggested, on the denuded surface of the crystalline series.

From the gneiss in the valley of the Pabar, the dip rapidly flattened, and continued flat all the way to Chergao (Chárgáon), elevation 6,100 feet. The rocks are somewhat micaceous quartzites of a dark-grey neutral tint colour, in which the mica is very subordinate. From thence to Roru (elevation 5,250 feet), the dip, at first a very low to north-east, suddenly rose to 50° beyond Mandári, and then became perpendicular. The dip fell again rather suddenly to 35°, which lasted for some distance, and then gradually flattened to a very low north-east-11°-north dip. From Mandári the rocks are thin-bedded micaceous silicious schists. In the side ravines at Roru are some dark carbonaceous-looking schists brought down from the hills above. At Roru the dip is flat, and the thin-bedded mica-schists are often as straight and regular as the courses of bricks in a house. On the road to Sungri, with a few local exceptions, the dip is for some distance flat; afterwards the average dip is 25° east-south-east. Mica-schists all the way.

Proceeding in the opposite direction to Deora (capital of Jubal State), the dip is in general flat, though occasionally it is low to north-east and sometimes north. Now and then boulders of the "central" gneiss on the road side áttest the presence of that rock in the hills above. Mica-schists all the way. I have also been from Roru up to the iron mines at Shiel, and thence down to Deora. Under Shiel I came on blocks of the "central" gneiss, but owing to grass and cultivation the gneiss did not crop out *in situ* on my actual path. I think there is probably a fault between the central gneiss of the upper Pabar valley and the gneiss to the west of Roru.

The gneiss, as previously described, crops out round the head of the Deora valley, and shows high up on the Kuper peak. I have also shown how a sudden change in the dip brings it out, on the opposite side, on the spur running out from the Kuper.Kánchu range in the direction of Chepál. On the Kuper-Kánchu spur, the outcrop extends from 9,620 feet to 8,000 feet. The nearest point on the Chor is Serai (Serán) (elevation 7,250 feet), and the outcrop of the granitoid gneiss there is on a level with, or a little above Serai. The distance, as the bird flies between the two points, is between 10 and 11 miles. The Chor gneiss answers well to the "central" gneiss in general characteristics. I feel satisfied myself that the granitoid gneiss of the Chor is simply an extension of the central gneiss beds I have been tracing out in this paper.

If this be so, does not this fact strengthen the view that the Krol, Infra-Krol, or Blaini rocks, between the outcrops of the central gneiss on the Chor and the Kuper-Kánchu range, rest on the denuded surface of the central gneiss series, and that the Chor and Kuper-Kanchu range were mountains standing up (far under the surface perhaps) of the Krol and Blaini seas?

If this view be correct, may we not suppose that the thickness of the Chor gneiss is not as great as it seems to be, but that it is, probably, simply an anticlinal in the gneiss, now masked by the metamorphism which has obliterated all traces of bedding.

In conclusion, I would venture to express the opinion that the metamorphism of the "central" gneiss is due to plutonic heat. The manner in which, as before described, the direction of the axes of felspar crystals changes, as the metamorphism increases, appears to me to indicate a freedom of motion which the constituent minerals could hardly have possessed unless the rock had been heated to a point approaching fusion. In the Satlej valley the signs of granitic intrusion into the central gneiss region are abundant, and they are not, I think, altogether wanting in the Chor. In the bed of the stream below Chaita (on the southern flank of the Chor), there is a huge block of the gneiss 67′ × 62′ × 37′. It is penetrated by granite veins which run at various angles; the principal one, about 4 feet wide, has caught up a fragment of the porphyritic granitoid gneiss in its passage, and this shows in the middle of the vein. This surely is an intrusive vein and not one due to segregation.

The presence of granite veins in the central gneiss of the Satlej valley and of the Chor seems to me to indicate that the central gneiss was at one time well within the action of the more deep-seated plutonic forces, and that its metamorphism is due to plutonic heat. If so, the Krol, the Infra-Krol, and the Blaini rocks cannot be older than the gneiss, and cannot really underlie it, whatever the appearances at certain points may be.

## VIII.—Chini to Jángi.

My paper has already extended to such length that I must be brief in my remaining observations. Following the right bank of the Satlej, from Chagaon past Chini, the rocks all the way to Pángi are "central" gneiss alternating with schists of the mica-schist series. Near Chagaon there is a broad dyke of granite, and the signs of granitic eruption now become numerous. At Pángi the "central" gneiss is much twisted about by the rising granite, which high up in the cliffs overhanging Pángi is seen bursting through thin-bedded mica-schists. The mica-schists are much darkened by the passage of the granite.

Between Pángi and Rarang there is profuse granitic intrusion, and the rocks are riddled with granite veins in all direction. Beyond Pángi there is a broad dyke of whitish granite, and as it is neared the felspar in the gneiss is scattered about in its matrix in a most remarkable way. About ¾ of a mile on the Pángi side of Rarang, a dyke, 300 or 400 feet wide, cuts clean through the thin-bedded mica-schists up to the crest of the mountain, sending out large lateral dykes into the schists.

A little beyond Rarang the great eruption has taken place, and it extends from this point all the way to Jángi (8 miles by road—see the Trigonometrical Survey Sheet No. 65). The schists cling, here and there, to the face of the granite, and form subordinate spurs, round which the road at times winds; but the whole core of the mountain, extending from Rarang on the south-west sides of the Gongra peaks to Jángi on the north-east side of those peaks, is all granite. How far it extends in a north-westerly direction along the Gongra range I cannot say, but it evidently does not extend beyond Jángi along the Lipe road, as the natives told me the rocks in that direction were all *katcha* (friable).

I was not able to examine the left bank of the Satlej opposite Rarang, which I longed to do, but as far as I could judge by the eye, the granitic eruptions seemed to extend to the south, and I should not be surprised if the lofty Raldang peaks, which rise to the height of 21,250 feet and tower over the traveller within 6 miles of the road, were formed in whole, or in part, of this eruptive granite. That the great mass of granite between Rarang and Jángi is a truly eruptive rock I do not doubt. Between Rarang and Jángi I found numerous blocks of mica-schist caught up by and buried in the granite. They are of all shapes, and varied in diameter from 2 inches to 2 feet. These blocks are identical in appearance and composition with the mica-schists through which the granite passes, and cannot, I apprehend, be due to segregative action.

### IX.—Microscopical characters of the Gneiss.

In connection with the foregoing field observations, I have prepared many (over 220) thin slices of rocks for examination under the microscope. Latterly I have turned my attention to the central gneiss. Speaking generally, the internal structure of the rock—particularly when it passes into a granitoid state—is that which has usually been described as characteristic of an igneous rock.* The crystals of felspar and quartz contain within them micro-crystals pointing in all directions. Liquid cavities are often numerous, and they frequently contain bubbles that move about restlessly, similar to those described by Sorby and others.†

Sorby has shown in his paper on the microscopic structure of crystals (Vol. XIV, Q. J. G. S., p. 453) that those bubbles have been formed by the "contraction of the fluid on cooling." Air and gas bubbles are readily distinguished under the microscope from vacuum bubbles.

I note the presence of these fluid cavities and bubbles, because I wish to draw from this fact the inference that the central gneiss has been subjected to the influence of heat. This influence may, I think, be drawn from the cavities I have observed in these rocks. These cavities appear to have been filled with a mixture of steam or highly heated water, and air or gas, and the two substances have separated on cooling.

That the heat was very great, and reduced the rock to a plastic condition, may be inferred from the presence of what Sorby calls glass cavities. In these it is seen that the glass or mineral matter formed contraction-bubbles on cooling, similar to those in liquid cavities; only, in the case of glass cavities, the bubbles are never movable, there are often more than one of them in the same cavity, and they are not always spheres. Frequently, then, their shape conforms to that of the crystal or glass cavity in which they are contained.

Sorby remarks of glass and stone cavities: "Independent of the fact that in all essential characters they are identical with the crystals in artificial furnace slags, their very nature proves the igneous origin of the minerals containing them. This is especially the case with glass cavities, for nothing but igneous fusion could so liquefy the enclosed glass that perfectly spherical bubbles could be produced."

The presence of cracks in micro-crystals, where the cracks have not extended into the matrix, as occurs in several of my specimens, is also, I think, good evidence of the rock having been subjected to great heat. Subsequent to the cracking the pieces have been severed and floated to some little distance from each other. This proves that the matrix was in a limpid condition and flowed in between the fractured ends so as to leave no trace of the disturbance. All these cracks were, I apprehend, caused by unequal tension either on the cooling or re-heating of the mineral. In one case the fractured pieces (one of which contains a bubble) appear to have lost the sharpness of their outline by re-heating, whilst two pieces have been soldered together.

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* I do not mean to imply by this either that the ock s an intrusive one that this structure cannot be produced otherwise than by dry heat. The fact noted mplies that, from whatever cause, the molecules had perfect freedom of motion.

† There is, unfortunately, neither time nor means to reproduce the excellent drawings of these objects sent by Colonel McMahon.—H. B. M.

Another curious class of crystals has been observed. At first sight they would seem to be illustrations of what Sorby calls stone cavities; that is to say, one mineral held in solution by another in a state of fusion and deposited on cooling. But as the dark opaque mineral is sometimes seen uninclosed by crystals and at other times is attached externally to crystals, I conclude that the dark minerals were first formed and the crystals were afterwards formed around them, or they were both floating about in a plastic state in the matrix and the dark minerals were absorbed into the white ones. I infer that the dark mineral was in a plastic state when the white mineral formed around it, or absorbed it into its own body, from the fact that where the dark mineral touches the outer sides of the white crystals, its surface generally conforms to the outline of the containing crystal as closely as if it had been deposited from a solution within the crystal itself. In one case when one of the dark minerals is seen riding astride on the back of a white crystal, it was observed that it had embraced the rounded form of the latter.

The study of the belonites contained in the felspar of the granitoid gneiss satisfies me that the central gneiss in its granitoid form was reduced to a plastic condition. Some of these belonites are very long, and occupy, in length, three or four fields of the microscope. Examples of belonites fractured and thrown out of their orignial position are not uncommon. Some can be distinctly traced to the physical strain of one belonite on another. These are not cases of irregularities of growth, but of distinct fracture after the formation of the belonites. A very striking instance (a most convincing one when actually seen under the microscope) occurs in which one of the fractured pieces is turned nearly at right angles to its original direction. The matrix must have been in a perfectly plastic condition to have allowed of this movement and to have flowed in round the fractured ends so as to leave no trace of the disturbance. I cannot believe that these fractures were simulated at the original formation of these crystals. I would as soon hold that the dip and contortion of strata are due to peculiarities in the original deposition of the beds.

The facts detailed in these observations show, I think, that the central gneiss has been subjected to great heat, and that where it passed into a granitoid condition, it became perfectly plastic.

In view of these results I think it would require strong evidence to justify the belief that the unaltered rocks of the Krol and Infra-Krol series underlie the crystalline rocks of the Central Himalayas.

The glass cavities, belonites, &c., described in these rocks, were seen under a magnifying power of 450 diameters.

## REMARKS, EXPLANATORY AND CRITICAL, ON SOME STATEMENTS IN MR. WYNNE'S PAPER ON THE TERTIARIES OF THE NORTH-WEST PANJÁB IN RECORDS, VOL. X, PART 3, BY W. THEOBALD, *Geological Survey of India.*

In Mr. Wynne's interesting sketch of the tertiary rocks of the North-West Panjáb, there are a few points whereon I should like to make some remarks in correction, as I believe, of some of the views adopted.

Under the head "*Erratics*" (page 123 *l. c.*), Mr. Wynne enumerates numerous examples, regarding whose origin and character there can be little doubt, save with those who altogether decline to recognise the existence of glacial conditions in Northern India during recent times; but, in addition to these, my colleague describes others, which are not only, in my opinion, not 'erratics' at all, but belong to diverse geological epochs.

The erratics of the North-West Panjáb, properly so called, and to which I would restrict the term, are composed of the crystalline rocks and slates of various sorts forming the hills which stretch away to the north, or of other rocks, such as limestone, greenstone, &c. (but not granite), outcrops of which are known to occur in the adjoining region. More or less rounded, and not unfrequently sub-angular, blocks of these rocks of all sizes, from 1 to 50 or 80 feet in girth, are met with in the Potwár and the country to the north, some details respecting which I have given in the same number of the Records (page 140); but, in addition to these undoubted travelled blocks or 'erratics' properly so called, my colleague, Mr. Wynne, at page 124, alludes to "*smaller and less angular erratic blocks of red granite*" as being common south of Mt. Tilla and Rotás, and specifies one 7 feet in height and 19 feet in girth near the Collector's bungalow at the Mayo Salt Mines at Kewra.

Now, I quite agree with the supposition that "*these red crystalline boulders*" are derived from the "*cretaceous or olive group of the Eastern Salt Range,*" though not without a *caveat* as regards the large block at Kewra. This block rests on the salt marl, and though it may have been derived from the 'olive group' by the simple removal, by denudation, of the intervening shales and sandstones, it is, in my opinion, equally probable that it has weathered out *in situ* from the boulder bed which in so many places covers the 'purple sandstones' immediately overlying the salt marl and is itself covered by the '*obolus* beds.' Conglomerates, with red granite and purplish porpheries, from some unknown source, are found along the Salt Range from palæozoic times down to recent, and the only thing that favors the cretaceous age of the Kewra block is that, from its size, it owes its transport not improbably to ice, and the olive series has yielded proofs of glacial agency, which the older beds have not done as yet; but there is no connection between this possible 'erratic' of cretaceous age and the 'erratics' of the district proper. Both it and the similar boulders from the olive group are simply weathered out of beds in the neighbourhood, out of the outcrop of clays or conglomerates of palæozoic, mesozoic, kainozoic or recent age, and *are neither met with in the area wherein the true 'erratics' abound, nor do the northern erratics occur mixed with these within their own* (*i. e.*, red granite boulder) *area*. A sharp contrast exists between these red granite boulders and the '*erratics*' of the Panjáb, properly so called, both geologically, geographically, and physically.

The difference between my colleague and myself is one more of definition and terms than of fact; but it is one which I am not inclined to lose sight of.

Regarding my discovery of an ice-scratched boulder of red granite in the cretaceous group, Mr. Wynne's words require a little explanation: "One such boulder polished and striated apparently by glacial action was shown me by Mr. Theobald, who found it in *a wall* near Wahali, on the eastern plateau of the Salt Range, not far from where the conglomerate just mentioned is *in situ*." The fact is that near Wahali the cretaceous boulder clay (much resembling the Talchir boulder bed in some respects) constitutes the sub-soil in some fields, and the boulders are simply gathered out of the field to clear it, and piled as a low wall along the roads, and in such a situation it was (virtually *in situ*) that my eye was attracted by the glitter of the *striated surface*, wetted by a passing shower.

An '*erratic*' this block doubtless was, *quoad* its original derivation and deposition in the 'olive' series, but it is not an '*erratic*' as regards existing conditions, or to be classed on the category of Potwár erratics.

Equally inapplicable, in my opinion, is the term '*erratic*' to the red granite blocks scattered about Tilla and Rotás. Their original source is, I believe, unknown, though they may have possibly come from the Arvali ranges. Their more proximate origin is from the denuded boulder clays of the cretaceous group in the Salt Range, or from still older beds such as I have already alluded to as covering the palæozoic "purple sandstone" of the Salt Range.

As regards, however, the so-called red granite erratics scattered over the country south of the Tilla ridge and Rotás, the *actual immediate source* is in the coarse upper Siwalik conglomerates which are there exposed, and in which both red granite and nummulitic limestone pebbles occur, as I have myself seen both north of the Bunhar River and also between it and the Chambal range.*

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NOTE ON THE GENERA CHŒROMERYX AND RHAGATHERIUM BY R. LYDEKKER, B.A., *Geological Survey of India.*

At page 77 of the tenth volume of the Records I noticed a molar tooth which was brought from Sind, and which corresponds to the larger of certain specimens of teeth from Sylhet figured under the name of *Anthracotherium silistrense* in the second volume of the second series of the "Transactions of the Geological Society," and which figures are copied on plate LXVIII of the "Fauna Antiqua Sivalensis."

The teeth so named and figured were subsequently referred by M. Pomel to a new genus, *viz.*, *Chæromeryx*; he simply says at page 687 of the "Comptes Rendus" for 1848, *Chæromeryx* = *Anthracotherium silistrense*: the assumption here being that all the teeth called *A. silistrense* belonged to *Chæromeryx*.

On examining the tooth from Sind for the purpose of figuring it, I observed that it did not agree with M. Pomel's description of the molars of *Chæromeryx*. The Sind tooth has five columns, and is bunodont; now, M. Pomel, in speaking of *Chæromeryx*, says: "*Molaires supérieures à quatre mamelons seulement, au lieu de cinq.*" It is therefore clear that the Sind tooth cannot be *Chæromeryx*.

On again turning to the figures of the original specimens (F. A. S., plate LXVIII), I find that those in the Fauna Antiqua Sivalensis are more clear than the originals, and that they show that these teeth really belong to two distinct genera; the single large tooth (fig. 23) being bunodont and having five columns on the crown, and the smaller teeth (fig. 22) being selenodont and with only four columns. This difference appears to have escaped M. Pomel, who followed Pentland in referring all the specimens to one species.

The Sind tooth agrees with fig. 23, and belongs to the *Anthracotheridæ*; and seems to be nearest to the genus *Rhagatherium*, to which I am inclined to refer it. This specimen will be subsequently figured.

The smaller teeth, which alone belong to *Chæromeryx*, seem to me to be so close to *Merycopotamus* that I cannot but think they belong to a smaller species of that genus.

The changing of the genus of the Sind tooth does not of course interfere with the inference drawn as to the relation of the Sind and Sylhet deposits.

To the Sind tooth and of course the similar specimen figured in plate LXVIII, fig. 23, I propose to assign the specific name *Sindiense*, and for the present, at all events, to place it in the genus *Rhagatherium*.

The specific name *Silistrensis* will of course apply to the selenodont teeth from Sylhet, whether they be subsequently referred to *Chæromeryx* or *Merycopotamus*.

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* From a private note from my colleague, Mr. Wynne, I gather that he never found these red granite boulders *in situ* in the conglomerates, whence he not unnaturally treated them as '*erratics*.' I was more fortunate, though not till after long and patient search. They are rare *in situ* when compared with the number scattered about, some being nearly 2 feet in diameter east of the Chambal range and south of Nonpur (on the Bunhar River); *but then* they are very imperishable articles, and those scattered over the surface represent the waste of almost cubic miles of conglomerate!

Under these circumstances, therefore, I do not think these red granite boulders can be termed '*erratics*' unless we fall back on the hypothesis that all of these have been '*erratics*' during a former and wholly different phase of geological life to that which we at present have to describe and deal with.

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E. MOCKLER, *Major,*
*Political Agent, Gwadur,*
(through W. T. BLANFORD, ESQ.)

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